WiM-Med

USER MANUAL

V 1.1

Herrero, J., Aguilar, C., Millares, A., Egüen, M., Carpintero, M., Polo, M.J., Losada, M.

December 2010

Grupo de Dinámica de Flujos Ambientales
Centro Andaluz de Medio Ambiente (CEAMA) – University of Granada - Spain

Grupo de Dinámica Fluvial e Hidrología – University of Córdoba - Spain

Table of contents

Table of contents 3

List of figures 4

List of tables 5

1. Introduction 6

2. System requirements and performance 8

3. Set-up 9

4. Data Organization: Wim-Med Project 10

5. Graphical environment 11

6. Running a case study 12

Project 13
Project Properties 13
Project tree 19
Results 30
Printing. Print preview. 34

Appendix A. Organizing the information. 35

Appendix B. Format of data files. 40

Raster-map files 40
Sequence Files 41
Aquifers file (h1) 42
Files of meteorological stations (m1) 43
Meteorological data files 43
File of weather events (m2) 44

Appendix C. Spatial structure of calculations 46

General scheme 46
Cells with surface balance 48
Cells with circulation on slopes 49
Cells which contribute to aquifers 50
Point flow results 50
Results distributed by cell 51

List of figures

Figure 1: About... 7
Figure 2. Set-up. Start-up screen. 9
Figure 3. Set-up. Selection of components. 9
Figure 4. Dynamic help label. 11
Figure 5. Display properties. 11
Figure 6. WiM-Med main window. 12
Figure 7. General and topographic properties. 14
Figure 8. Detailed topographic properties. 15
Figure 9. Meteorological properties. 15
Figure 10. Viewing an ASCII text file with the meteorological stations. 16
Figure 11. Soil properties. 16
Figure 12. Advanced soil properties. 17
Figure 13. Vegetation and hydrological properties. 18
Figure 14. Advanced hydrological properties. 18
Figure 15. River properties (floods). 19
Figure 16. Digital Elevations Model. 20
Figure 17. User map regions. 21
Figure 18. Aspects map. 22
Figure 19. Map of horizon height in the direction of NW-SE. 22
Figure 20. Sequence control toolbar. 23

List of tables

Table 1. Types of simulations allowed. 35
Table 2. List of data required, according to type of simulation. 35
Table 3. Data from the tree in the main WiM-Med window 36
Table 4. Data in the Project Properties window with codes. 38
Table 5. List of active intermediate variables, according to simulation type. 38
Table 6. List of active state variables, according to simulation type. 39
Table 7. List of active meteorological variables, according to simulation type 39

1. Introduction

WiM-Med *(Watershed Integrated Management in Mediterranean Environments)* is a program that allows us to simulate watersheds using a complete, distributed physical model. Working from daily and hourly weather data, it facilitates the spatial interpolation and temporal distribution of meteorological variables, the simulation of distributed hydrological processes that occur both on and under the ground, calculating the water balance in aquifers and the generation of groundwater flow, circulation on mountain slopes and river channels and the non-permanent study of rivers during flood events. The following soil processes are calculated in a distributed way: interception, snow, surface runoff, evaporation, surface infiltration, subsurface flow and groundwater recharge. As the name suggests, it has been developed with a view to becoming part of a technical tool which will facilitate, and also provide a solid scientific basis for, integrated watershed management. Thus, the WiM-Med model allows us to deal with every aspect connected with water and to transfer a specific combination of meteorological variables acting on a particular region to results which are both occasional and widely distributed in space, such as river water flow, volume of stored water or the size of flooded areas.

The WiM-Med model, although it can be applied to any watershed, has been developed in the basin of the River Guadalfeo, in the Andalusian Mediterranean Basin, and therefore special attention has been paid to faithfully representing the processes linked to a semi-arid, mountainous Mediterranean basin with snow, torrential rains, lengthy periods of drought, a notable presence of groundwater and a marked heterogeneity in all its physical properties.

The program is made up of two separate parts: a calculation module and a Windows viewer. The calculation module is an *expert* program, run by command line and interacting with the user through entry and exit files. It is responsible for carrying out all the calculations and hydrological simulations. The Windows viewer is a graphical environment that allows for more user-friendly interaction in data selection and preparation and in displaying results.

About WiMMed
WiMMed
WiMMed 1.1. English version. © 2010. All rights reserved by authors.
PHYSICAL MODELS WiMMed Cmd and Guadalfertran:
Grupo de Dinámica Fluvial e Hidrología. (UCO - CEAMA)
Grupo de Dinámica de Flujos Ambientales (UGR - CEAMA)
GIS AND VISUALIZATION ENVIRONMENT WiMMed:
Accept

Figure 1: About...

The *WiM-Med Cmd* calculation module has been developed and tested jointly by the Environmental Flow Dynamics Research Group of the University of Granada (Grupo de Dinámica de Flujos Ambientales, http://www.dinamicaambiental.com) and the Fluvial Dynamics and Hydrology Research Group of the University of Córdoba (*Grupo de Dinámica Fluvial e Hidrología*, http://www.uco.es/investiga/grupos/dinamicafluvialhidrologia/DFH/) and the University of Córdoba Hydrology and Agricultural Hydraulics Group. The Windows graphical display used by *Wim-Med* has been developed with the cooperation of Bermasoft.com. All of the above has been carried out as part of the Guadalfeo Project, funded by the Institute of Water of the Andalusian Regional Government's Ministry of the Environment.

2. System requirements and performance

WiM-Med is designed to work under the Windows operating system (XP or later). The disk space required for installing the basic program is minimal: 5 MB.

However, it is during the calculation with the simulation model when there is a greater demand on system requirements. In this case, both disk space and RAM memory, as well the as computing time required, depend largely on the number of pixels the study area is divided into, the number of days the simulation lasts and the number of calculation variables for which results are required. Therefore, it is practically impossible to fix any previous system requirements.

To give an example, we can state the specific requirements used during the simulation of the particular case included in the Guadalfeo Basin study. The study area in this case was made up of 1.5 million cells. The computer used was an AMD Athlon 2400+. The **free** RAM needed is 1.5 GB (2 GB total minimum, including Windows). The disk size required depends on the combination of the number of maps requested, calculation length and time scale in which the results are needed, given that each map in this basin takes up about 10 MB. Using these data, we can estimate that a calculation with hourly results, for example, would occupy 1GB of disk space for each variable and for each 4-day simulation period. The program automatically calculates the disk space needed in order to alert the user if there is any danger of running out of free disk space.

As far as processing time for the complete Guadalfeo Basin study is concerned (storing one variable per day), using the hardware described above, we estimate it took 10 hours of calculation per year simulated.

3. Set-up

The WiM-Med program is very simple to install, and uses the executable set-up file *wimmed_1.0.0.26.exe*. If you run this program, a set-up wizard (Figures 2 and Figure 3) opens where you can select the installation directory and the components to install.

WiMMed 1.1 Setup
Welcome to the WiMMed 1.1 Setup Wizard
This wizard will guide you through the installation of WiMMed 1.1.
It is recommended that you close all other applications before starting Setup. This will make it possible to update relevant system files without having to reboot your computer.
Click Next to continue.
Next >
Cancel

Figure 2. Set-up. Start-up screen.

The optional components include only the help file and the sample project, which is what takes up most of the installation, as it includes all the necessary data for carrying out the River Guadalfeo Basin simulation.

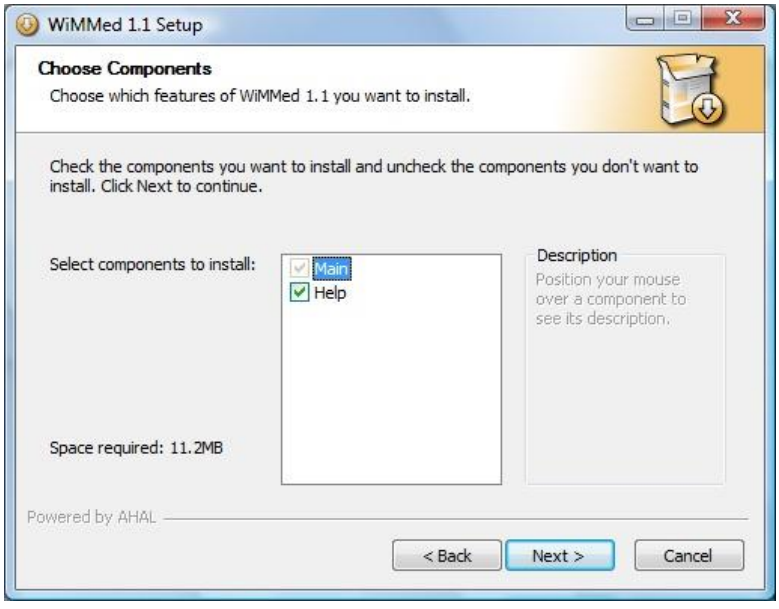
WiMMed 1.1 Setup
Choose Components
Choose which features of WiMMed 1.1 you want to install.
Check the components you want to install and uncheck the components you don't want to install. Click Next to continue.
Select components to install:
Main
Help
Description
Position your mouse over a component to see its description.
Space required: 11.2MB
Powered by AHAL
< Back
Next >
Cancel

Figure 3. Set-up. Selection of components.

4. Data Organization: Wim-Med Project

All the information with the data and results from the simulation in one particular region is collected together in what is called a **project**. All the files added to the project are copied into a folder with the same name as the project inside the directory *My Documents→WiMMed Projects*. In other words, each WiM-Med project will always work with its own copy taken from the duplicate of the original files. In this copy, the map files are always stored in WiM-Med binary format, in order to reduce their size and disk-access time.

The program directly processes and displays the information it generates. Thus, in the same way that new simulations associated with a project can be launched, folders of previous simulation results can also be deleted from inside WiM-Med. The corresponding result files will be automatically deleted from the computer, since they often occupy a large amount of disk space. In any case, an expert user can access all information connected with WiM-Med through Windows Explorer. In this way, all projects, with their data files and results, can be edited (deleted, copied, etc.). Each folder contains all the information relating to a project (data and results). This direct access is not recommended when using the program normally, and is only recommended for carrying out back-up copies or for deleting a project completely.

Uninstalling the product does not delete the projects created with WiM-Med, and these can take up a lot of disk space and must be removed manually from the abovementioned folder.

Loading a project and all its associated data (whether to open or edit it) should be carried out from the disk, and probably consists of a large amount of information. It is, therefore, quite normal that it takes a few seconds to load.

5. Graphical environment

The visualization of data and results share a number of features which belong to the WiM-Med graphical environment, which has been specially designed to present and manage distributed information in map form:

- Geo-referenced maps.
- Dynamic on-screen information using labels (Figure 4).
- Zoom and distance-measuring tool.
- Display layers with variable viewing options: color scale, scale limits, decimals, and so on. (Figure 5).
- Printing and Print Preview
- Storage of each case study in project form, with all input data and the different simulations which have been carried out.
- Simple installation with built-in example.
- Export, import and display maps in *raster ASCII-ArcGIS* format.
- Export of maps in most common graphic formats (jpg, bmp, tiff, etc.)

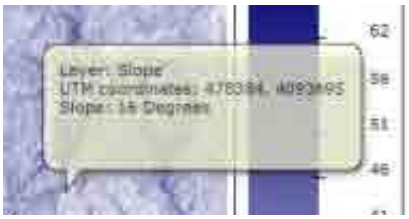

Figure 4. Dynamic help label

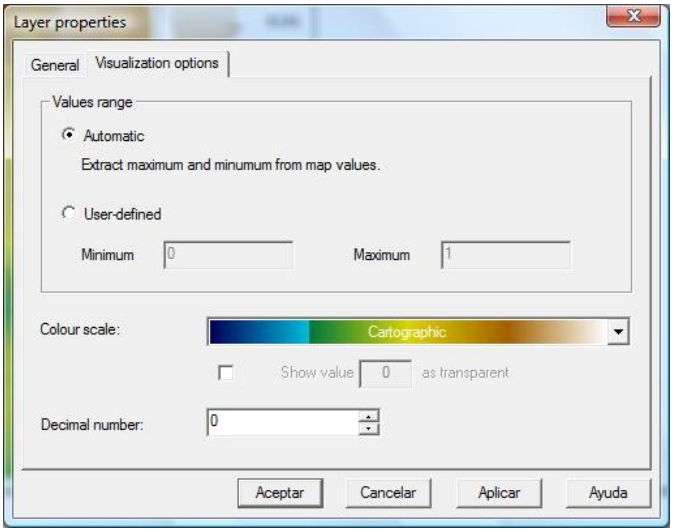

Figure 5. Display properties.

The main WiM-Med graphical interface is divided into 3 main sections, as shown in Figure 6:

- (1) **Project bar:** this is a tree which groups and orders all the input and output information. It contains folders with information, maps and sequences. The sequence is a set of maps which shows the temporal evolution of a particular geo-

referenced property. Thus, it can be viewed as a video in which each of its images is linked to a date.

- (2) **Map:** this area of the maps features geo-referenced display with information distributed by colour code This code appears on the side of the window, with reference to its units.
- (3) **Results bar:** this is the text window where the main results messages for the simulations in the different modules are shown..

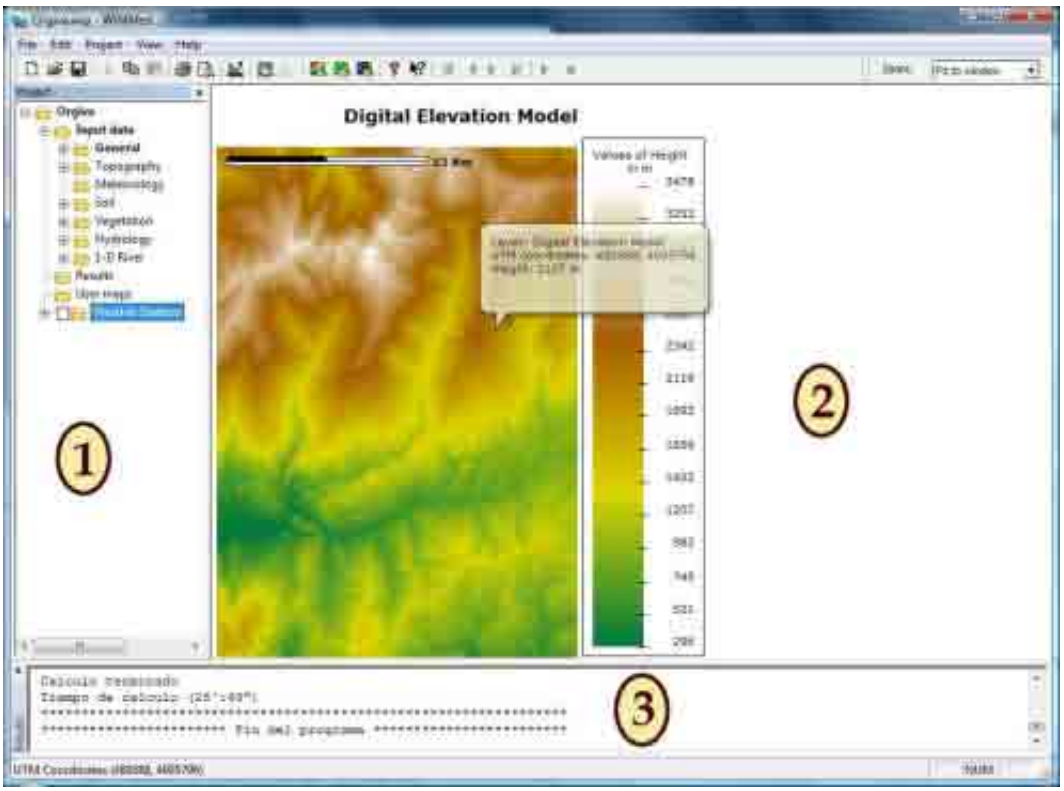

Figure 6. WiM-Med main window.

In addition, there is the usual **Status bar** at the bottom of the window, where useful information is displayed, such as, for example, the UTM coordinates of the mouse position on the map. Finally, there is also a **Menu** and a **Toolbar** at the top of the screen, where the different functions of the program can be accessed simultaneously.

All the *bars* mentioned (that is, all the graphic elements except the **Menu** and **Map**) can be enabled and disabled from the menu item *View*.

6. Running a case study

This chapter describes, in the style of a set-up wizard, how to load, handle and display data, run a simulation and visualize and export results. In this way, we can run through the program's functions while describing the data required for calculation.

Project

From the *File→New File→New* menu, you can access a tutorial where all the input data is asked for in sequence in order to create a new project. There is no need to specify all the project data for this tutorial mode (a Digital Elevations Model is OK), so that any data not yet defined can be loaded or modified afterwards from the *Project→Properties* option. The windows showing the project properties definition are the same both for a new project tutorial and for editing an existing one. These are dealt with separately in the next section.

An earlier project which has been saved can be loaded from the *File→Open File→Open* menu or from the "recent documents" area opened in the *File* menu.

Project Properties

Whether you start from the new project tutorial or from the properties menu of an active project, the windows which allow you to enter all the data needed for the simulation are the same.

These input data can appear in any of the following four formats: number, formatted ASCII text file, *raster* map or map sequences. The numerical definition of the parameters is displayed directly in the windows. The formatted text files must be edited previously following the instructions indicated for each type of data. *Raster* map formats must correspond to either of the following formats: ASCII-ArcGIS or binary WiM-Med.

The input data are grouped into the following categories: general, topography, meteorology, soil, vegetation, hydrology and river. Table 4 shows in detail the hierarchy of all the data. The property definition windows, in general terms, reproduce this hierarchy. In some of these main chapters, the sub-category *Advanced Properties* is included, which, in general, groups together the properties which correspond to calibration factors or those which are optional.

The first window (Figure 7) contains general properties and topographic properties. These include one basic item of data, namely the Digital Elevations Model DEM, in map format.

In all these project data entry windows, there is a yellow box at the bottom which shows expert information about the variable which is active (that which is being edited). This information includes a detailed description of the variable, its units, its format and, where applicable, it suggests a default value.

Data with non-numerical format need a text file to be introduced. On the right, there is a button with a triangle which allows you to find the file on the hard disk (*examine*) or to

view the contents of the selected file, but does not allow editing (example in Figure 10). Such editing should be carried out outside WiM-Med, using any ASCII text file editor.

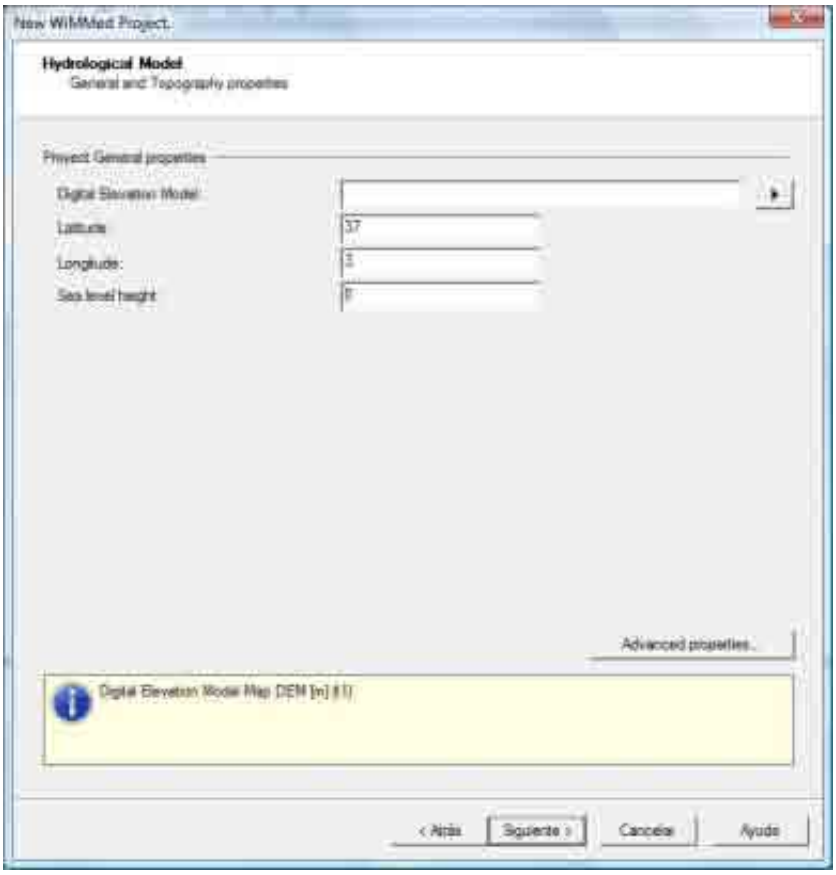

Figure 7. General and topographic properties.

The topographic properties category includes some advanced features which are shown in Figure 8. All the topographic data collected here can be calculated automatically by WiM-Med using DEM, so it is not necessary to define them. For the first simulation which is carried out without them, they will be automatically generated and stored in a results subdirectory in the project directory. This may take up a large amount of computing time, especially for the DEM correction for flat or depressed areas, and for constructing the DFM Digital Flow Model. To avoid having to repeat these calculations in successive simulations, you are recommended to include in the project maps created in the first simulation the project include through the advanced topographic properties shown in Figure 8. In addition, data generated by other external applications can also be incorporated into the project, taking care that the limits and number of cells of these maps are perfectly matched with those of the DEM.

In this type of table, you can browse for a file by using the button which appears on the right when a property is selected.

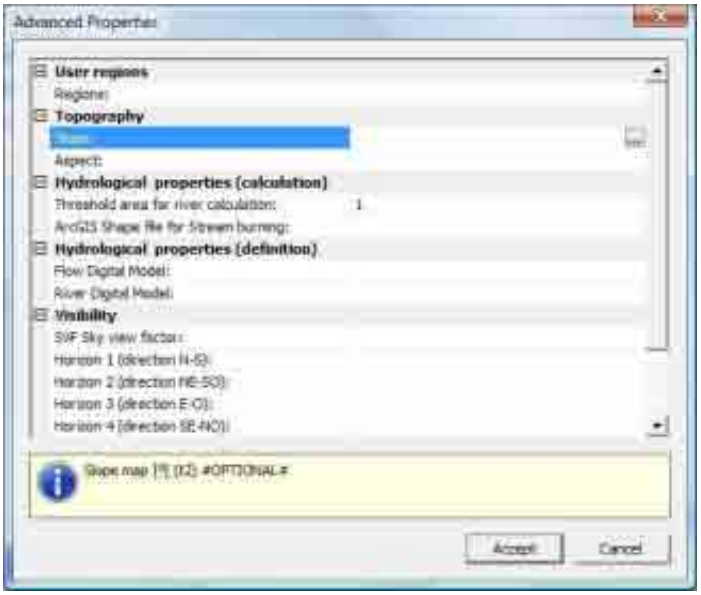

Figure 8. Detailed topographic properties.

Figure 9 shows the window through which the meteorological data are defined. All correspond to ASCII text files with the format specified in Appendix B. Figure 10 shows how WiM-Med presents a previously loaded ASCII text file, without allowing editing.

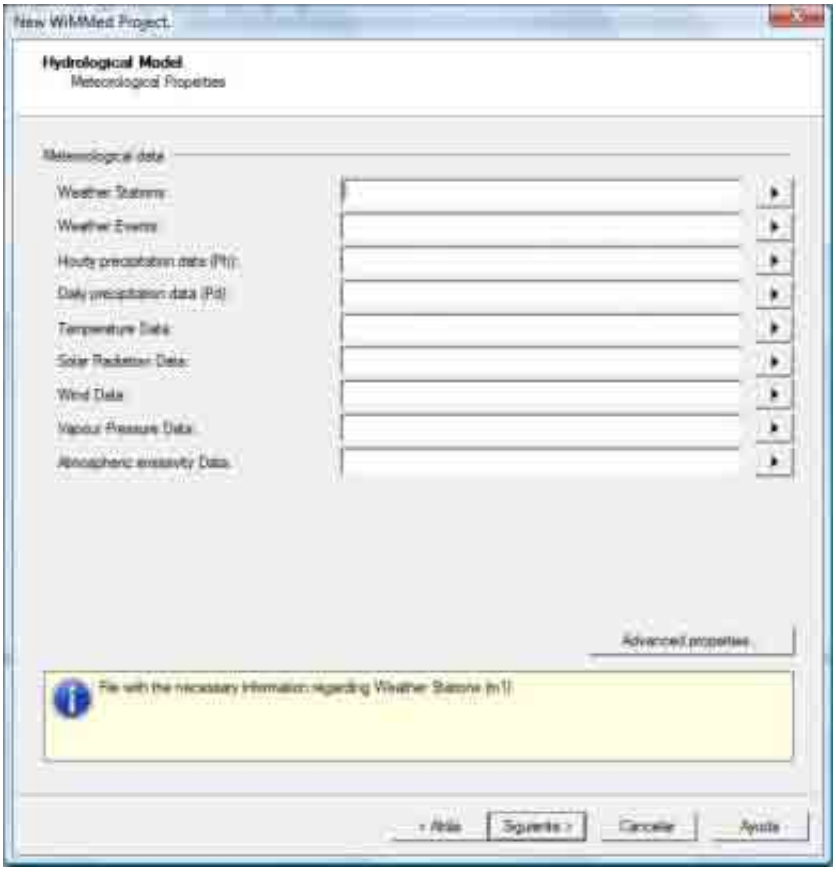

Figure 9. Meteorological properties.

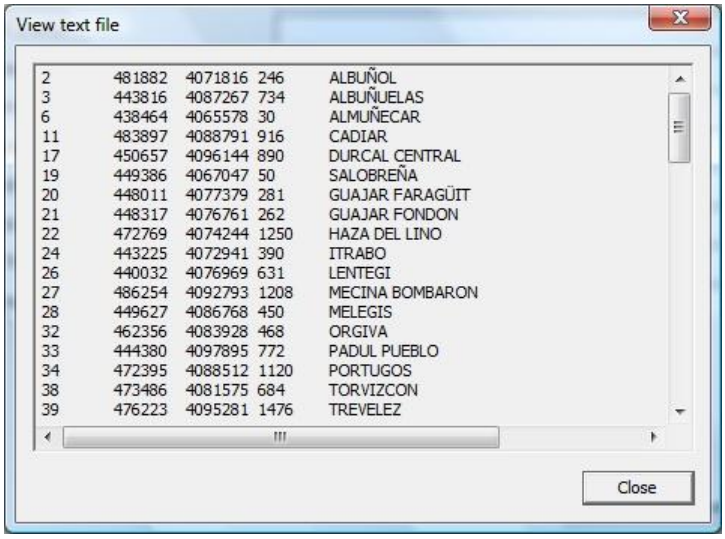

Figure 10. Viewing an ASCII text file with the meteorological stations.

Figure 11 shows the data input window with the basic soil properties, all referenced to maps. In addition, the advanced soil properties (Figure 12) include some numerical parameters for a range of soil calculations and calibration coefficients for the previous maps.

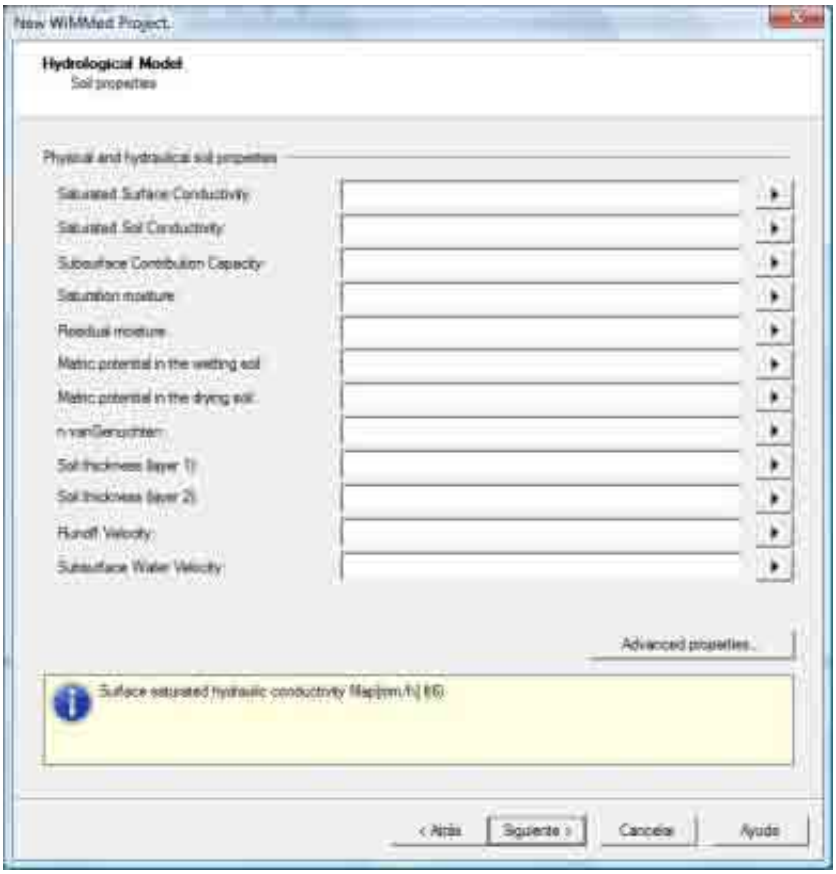

Figure 11. Soil properties.

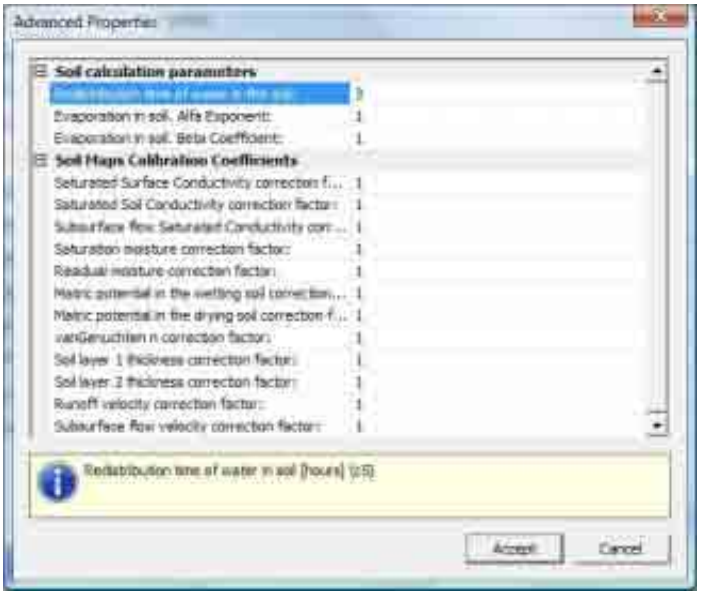
Advanced Properties
Soil calculation parameters
Evaporation in soil. Alfa Exponent:
Evaporation in soil. Beta Coefficient:
Soil Maps Calibration Coefficients
Saturated Surface Conductivity correction f...
Saturated Soil Conductivity correction factor:
Subsurface flow Saturated Conductivity cor...
Saturation moisture correction factor:
Residual moisture correction factor:
Matric potential in the wetting soil correction...
Matric potential in the drying soil correction f...
vanGenuchten n correction factor:
Soil layer 1 thickness correction factor:
Soil layer 2 thickness correction factor:
Runoff velocity correction factor:
Subsurface flow velocity correction factor:
Redistribution time of water in soil [hours] (≥0)
Accept
Cancel

Figure 12. Advanced soil properties.

The next window (Figure 13) lists the vegetation and hydrology properties. Under vegetation characteristics, there is a map with the maximum storage capacity of the canopy fraction and the two input items of data for a project which are defined as map sequences: the fraction of plant cover and the albedo. A sequence is defined through an ASCII text file which refers to a series of maps with the paired date-map sequence - Appendix B gives a detailed description of this format. The sequences are related to a particular temporal variability of the property. In this case, the variability of the plant cover is detectable from satellite image processing, together with its date. If a suitable series of images is not available, a single date-map pair with any date and a relevant map can always be included in the ASCII text file of the sequence, taken as a time constant.

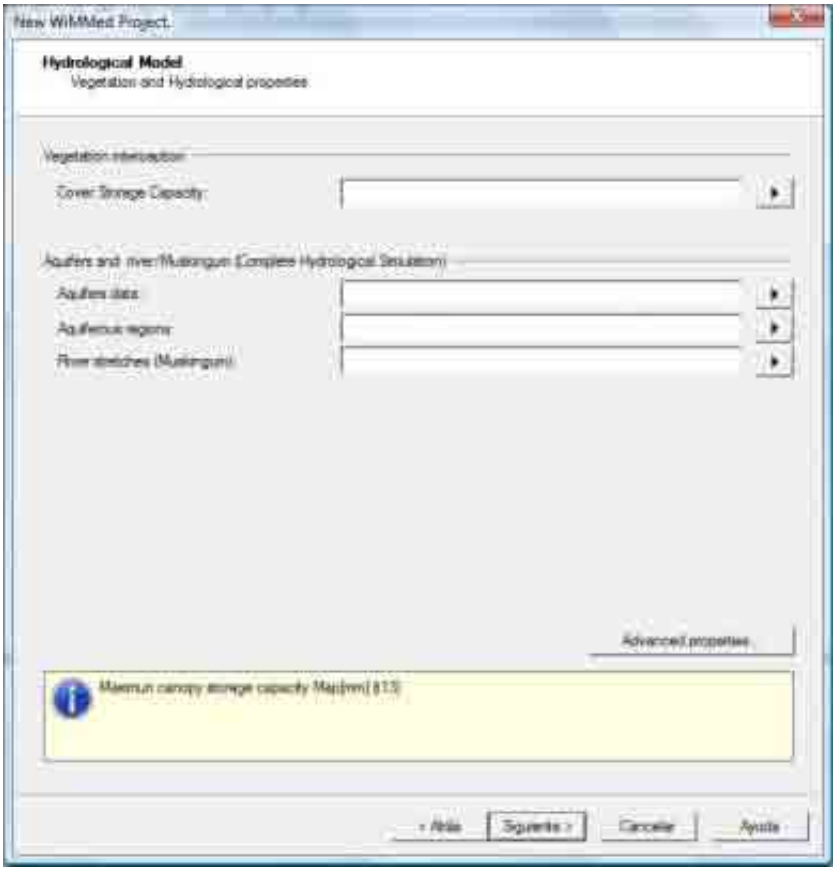

Figure 13. Vegetation and hydrological properties.

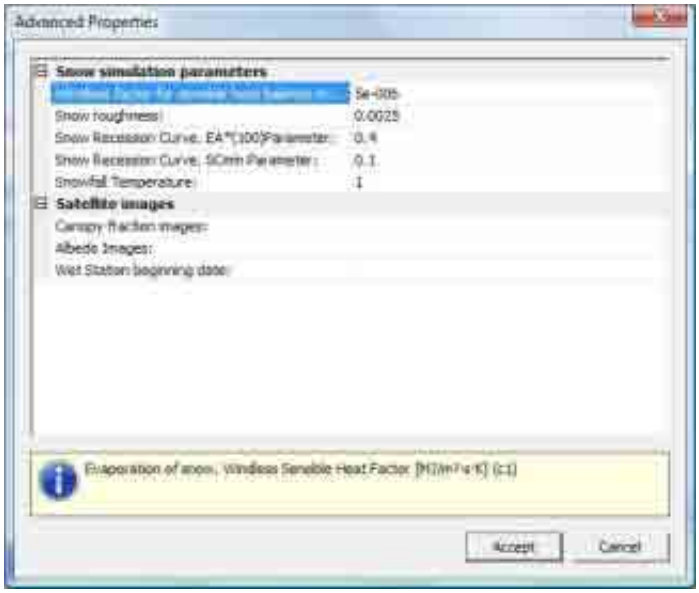

Figure 14. Advanced hydrological properties.

Finally, there are two ASCII text files with the properties needed for the river simulation with the one-dimensional non-permanent model (Figure 15).

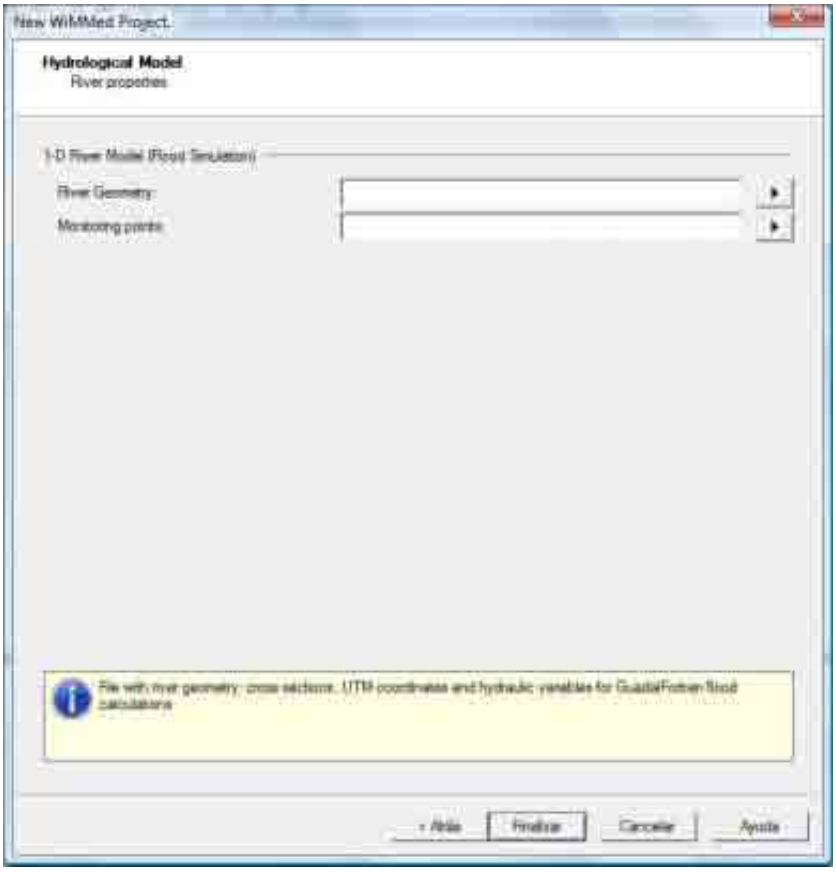

Figure 15. River properties (floods).

Project tree

The display of geo-referenced data (maps, sequences, and weather stations) is controlled by the project bar or tree. This appears on the left-hand side of the task window (Figure 6, area 1), and it shows the layers with data and results arranged in thematic folders. The management of the data within the tree, following the criteria outlined in the Project Properties, is detailed in Table 3 (Appendices section). At the highest level, there are the three main folders, which are *Input data, Results* and *User maps*. At the lowest levels are the relevant maps or map sequences. All the names in brackets refer to a folder or sub-folder.

The input data are grouped into sub-folders under the main categories in which all data are included: *General, Topography, Meteorology, Soil, Vegetation* and *Hydrology*.

The colouring order of the layers is top downwards. This means that the highest layers in the tree (DEM) are coloured first, and the lowest last, covering the previous ones. In any case, only the DEM layers, regions and weather stations can be permanently active. The remaining layers can only be activated one at a time.

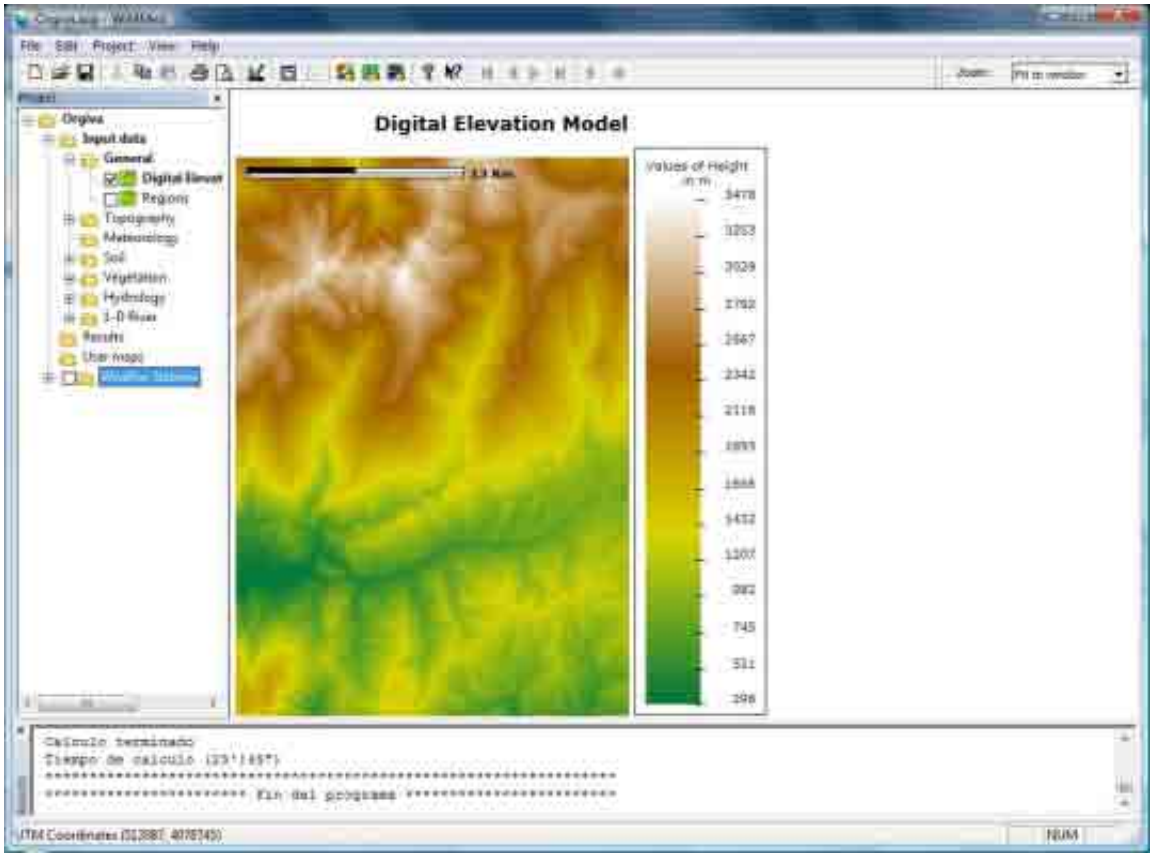

Figure 16. Digital Elevations Model.

In front of each map there is a selection box to enable or disable the display of that layer. Only the two layers in the General level can be permanently activated. For the other layers, activating one layer automatically disables the previously selected one. The layer display makes them overlap each other following the descending order of the tree. Thus, the layer with the digital elevation model DEM (Figure 16) is always at the bottom.

The DEM is the starting data for any project, since it is from this information that the extent, coordinate and accuracy (cell size) of all other maps are defined – both as input (which must coincide with it) and as output.

The other map included in the "General" category is that of User regions (Figure 17). This map simply serves to define the calculation area within the rectangular extension of the DEM and establish characteristic regions where added results can be included.

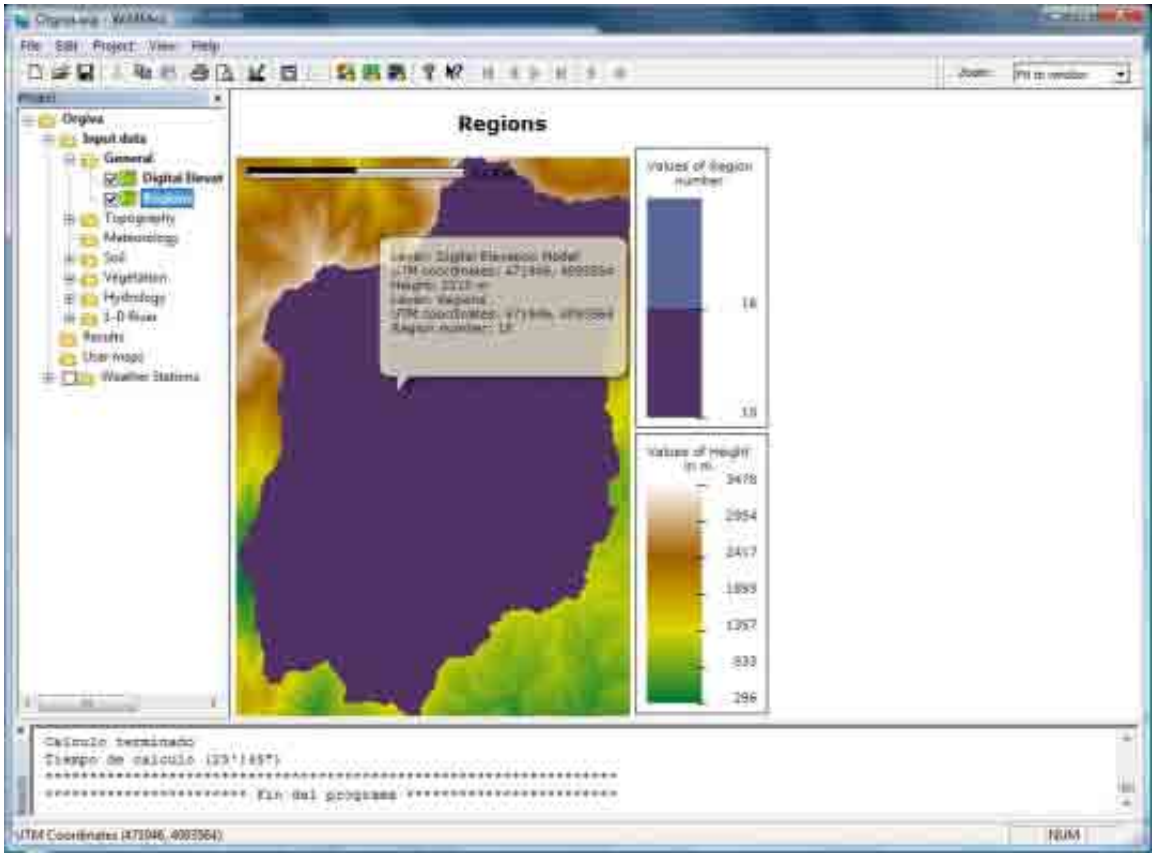

Figure 17. User map regions.

In "Topography" are included maps which bear a direct relation to the orography and the hydraulic network, which are both calculable directly from the DEM. Two examples of the maps included in this category are the map of aspect or direction of maximum slope measured from the south in a clockwise direction (Figure 18) and the map of horizon height in the NW-SE direction (Figure 19), which indicates the height in degrees which the horizon is at, at a fixed point looking from there to the SE.

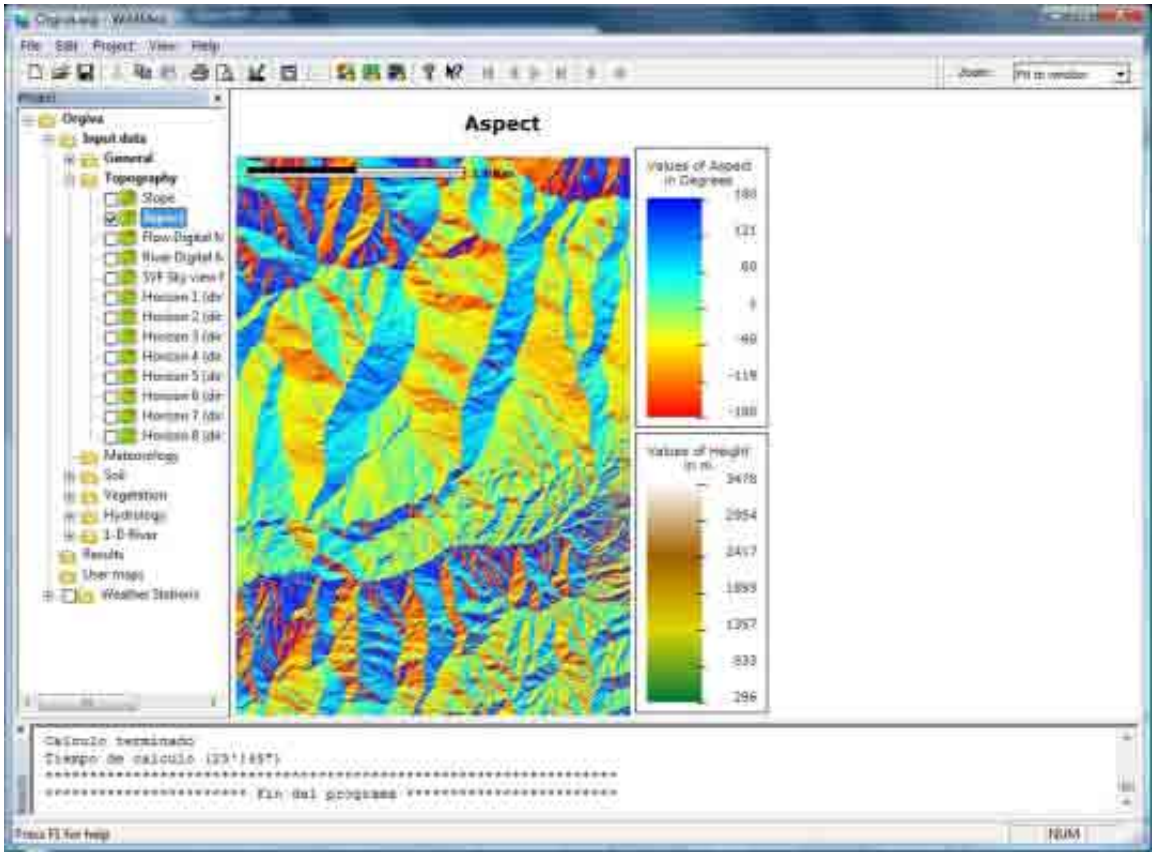

Figure 18. Aspects map.

Figure 19. Map of horizon height in the direction of NW-SE.

In the "Soils" category, the distributed data of the parameters related to soil hydraulic properties that influence surface runoff, subsurface and groundwater, storage and evaporation from itself are collected. Figure 21 shows one of these parameters: surface saturated hydraulic conductivity, which controls the balance between infiltration and surface runoff.

The "Vegetation" category includes information which helps us to measure the interception of rainfall by vegetation and albedo (Figure 22). This information is displayed as maps and two sequences: the albedo and the canopy fraction. The sequences are a set of maps showing one piece of land over different dates. Each date constitutes a map equivalent to a still video image. To move around the different dates or images, use the following control which appears on the Toolbar (Figure 20):

Figure 20. Sequence control toolbar.

It works in the same way as using a video, with frame-by-frame fast-forward and rewind, in both directions. With red controls, we can enable and disable the automatic playback for the sequence in video form.

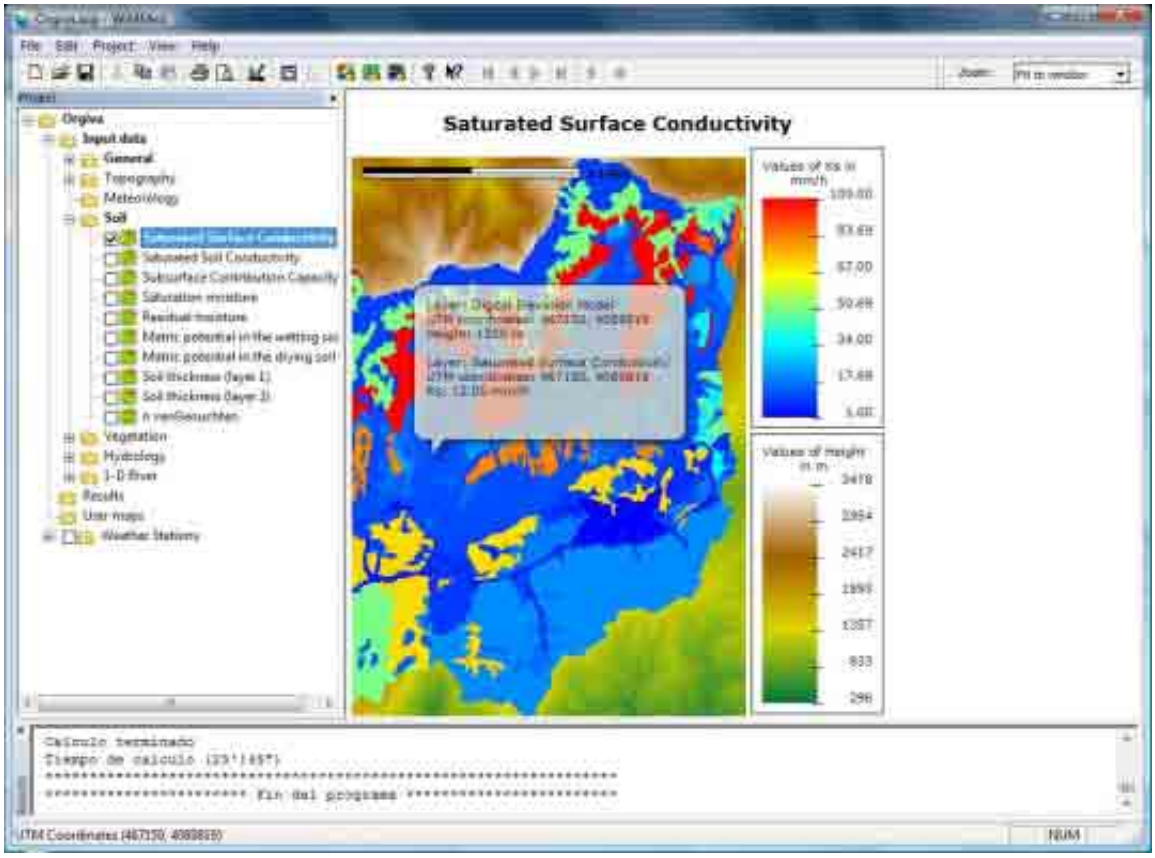

Figure 21. Map surface saturated hydraulic conductivity.

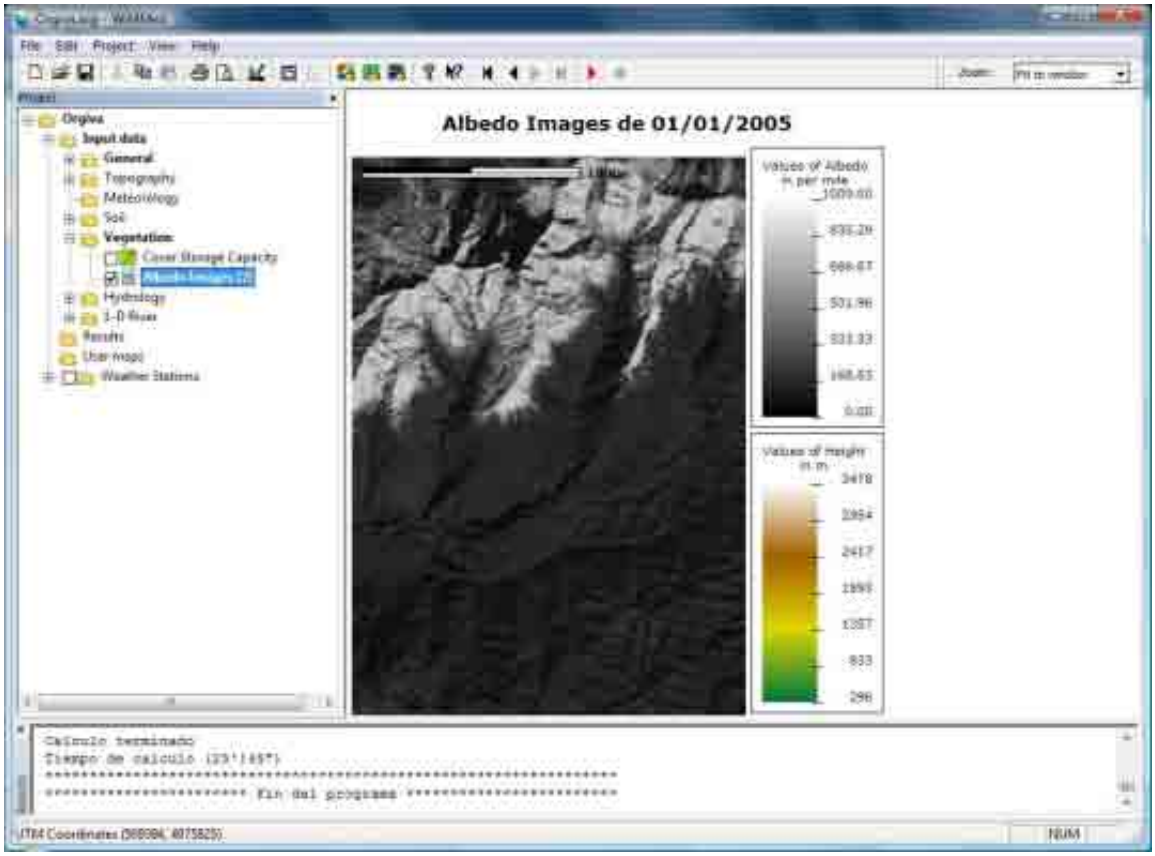

Figure 22. Map of the sequence of albedo images.

The last category is that of Meteorology. As well as a map with the Hargreaves coefficient and another that determines the spatial distribution of hourly precipitation, this category also includes the situation of the weather stations (Figure 23), despite the fact that this layer appears last on the project tree so that it is always visible above the rest. To make activation linked to the weather variable easier, there are sub-folders for each of these variables. Any station which measures more than one meteorological variable will appear repeatedly in all the corresponding sub-folders.

By clicking the right mouse button on any of the elements of the tree, a contextual menu will appear (Figure 24) from which you can carry out the following actions:

- *Exporting data.* Save the map as a raster file with ArcGis ASCII format.
- *Properties.* Change the map's graphical map allows you to choose a new colours scale, the lowest and highest limits of this scale, a transparency value for null values (optional) and the number of decimal places displayed on the scale and in the information about each dynamic label point (Figure 25).

Unless otherwise stated, the display limits are calculated automatically. In one sequence, these limits remain constant for all images, in order to allow a clearer comparison between them.

You can also obtain a representation of the maps in image file format (jpg, bmp, tif ,...) from the menu *File* → *Export Image*.

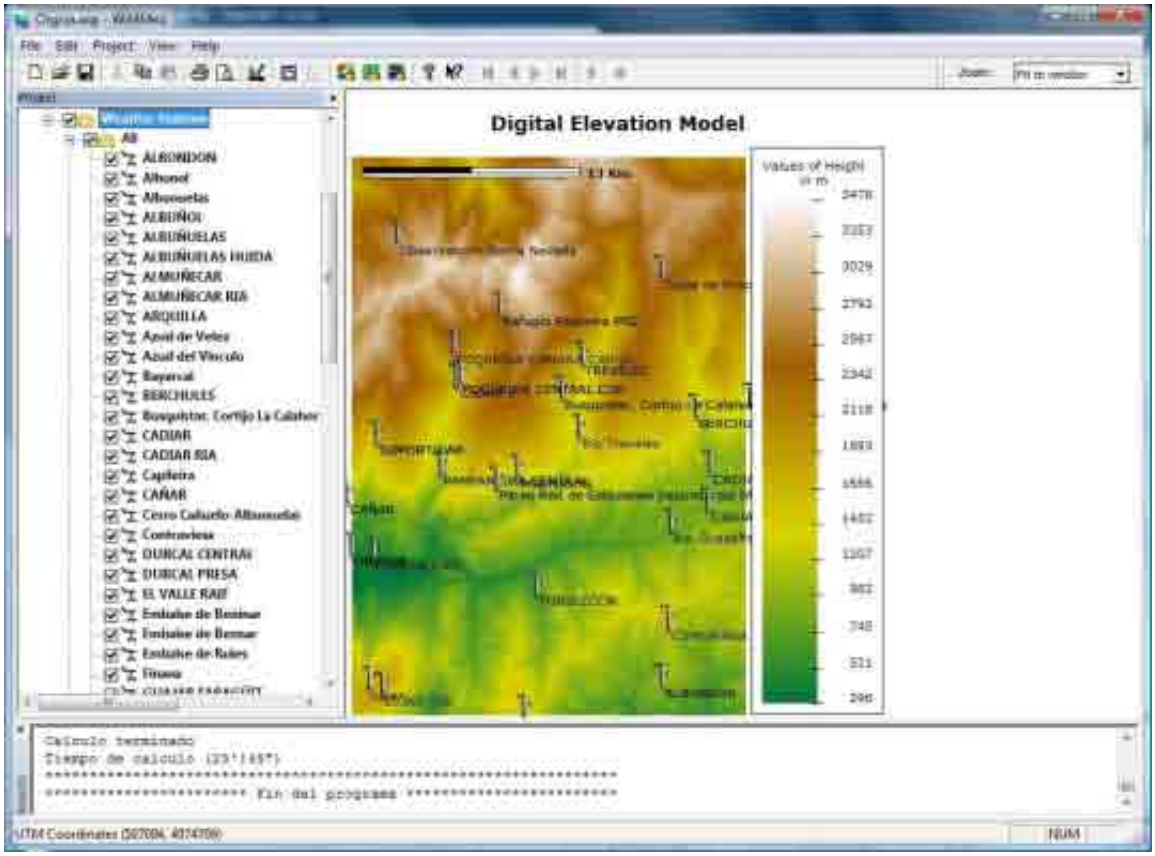

Figure 23. Weather stations.

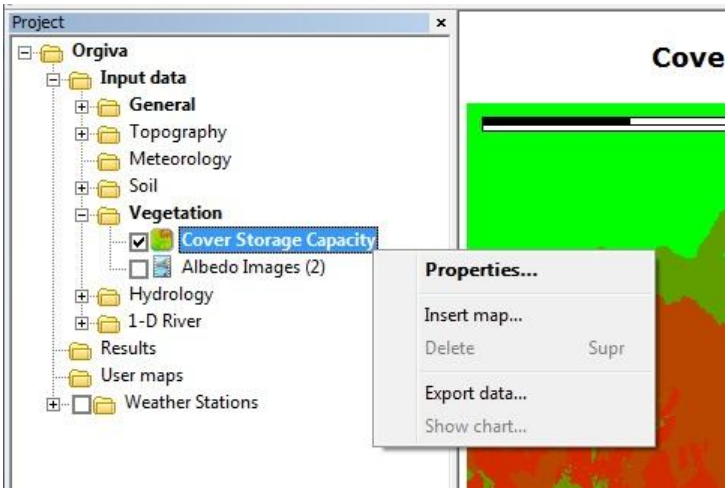

Figure 24. Contextual menu in the tree maps.

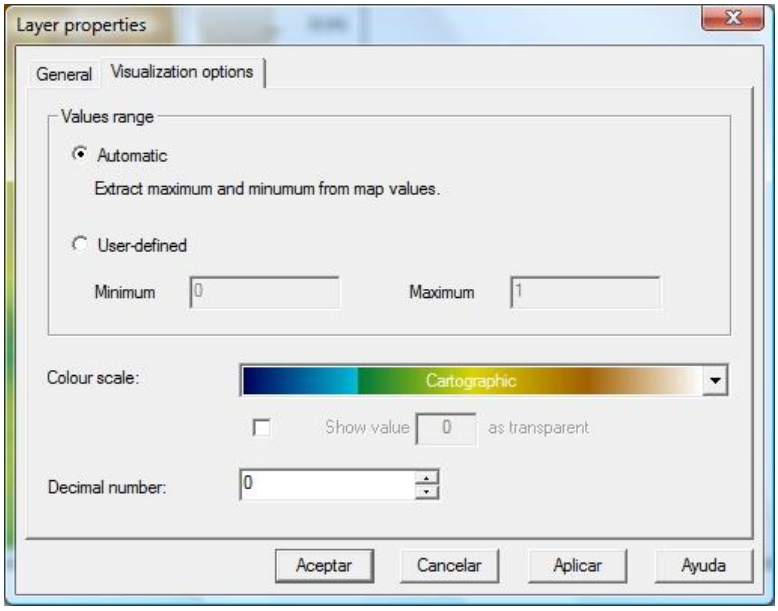

Figure 25. Options for displaying a map of the project tree.

Simulation

To run a simulation case, you can either start from the *Project→Simulation* menu, or with the following buttons on the toolbar:

The buttons, from left to right, represent the permitted types of simulation - which are described in Table 1 – as follows:

- Simulation of surface cycle
- Full-cycle simulation using Muskingum for the river routing
- *1-D r*iver simulation model

The surface cycle simulation is the simplest of all. It allows us to make calculations of the hydrological balance in each cell of the area studied without dealing with the generation of flow. In other words, calculating the estimated runoff and infiltrations for each cell, but without these circulating towards the channel and without calculating the groundwater in the aquifer. To carry out a simulation of this type, the element should be selected from the *Project→Surface Cycle Simulation* menu.

The following figures show the options available from the surface cycle simulation window, although these options are common to all types of simulation.

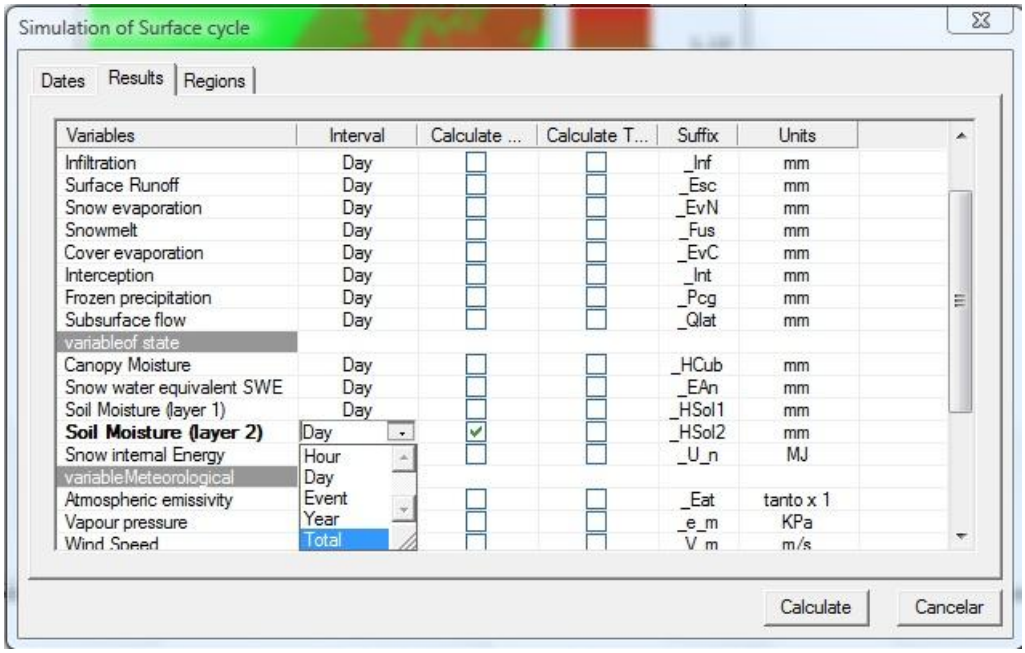

Figure 26. Surface cycle simulation. Variables.

The simulation results you need to save for study or to include in a report are selected from the variables tab (Figure 26). The variables for obtainable results depend on the type of simulation (see Tables 5, 6 and 7). Once you have chosen the variable you want to get results from, you must select the simplest (and fastest) simulation available.

From this window *(interval* column), it is also possible to choose the time scale for which you want the results: hourly, daily, by event, yearly or total (over the whole simulation period). The *calculation* column allows you to choose from distributed results in map form, or accumulated by region. The distributed results will be transformed into a map sequence, one for each time step according to the time scale selected. The accumulated results by region are based on the regions map defined by the user in the project properties (key g1, Figure 17) and present the average results for each region. Therefore, the result is displayed as a table in ASCII format where each column represents a region and each row a time step. The first column shows the average for all the regions. This file can be found in the results directory with a suffix after its name which refers to the variable it contains, according to the keys which are shown in Tables 5, 6 and 7.

The activation of a results variable means a significant increase in computing time as well as in the free disk space required if it is in map form (at a rate of 10 MB per map sequence).

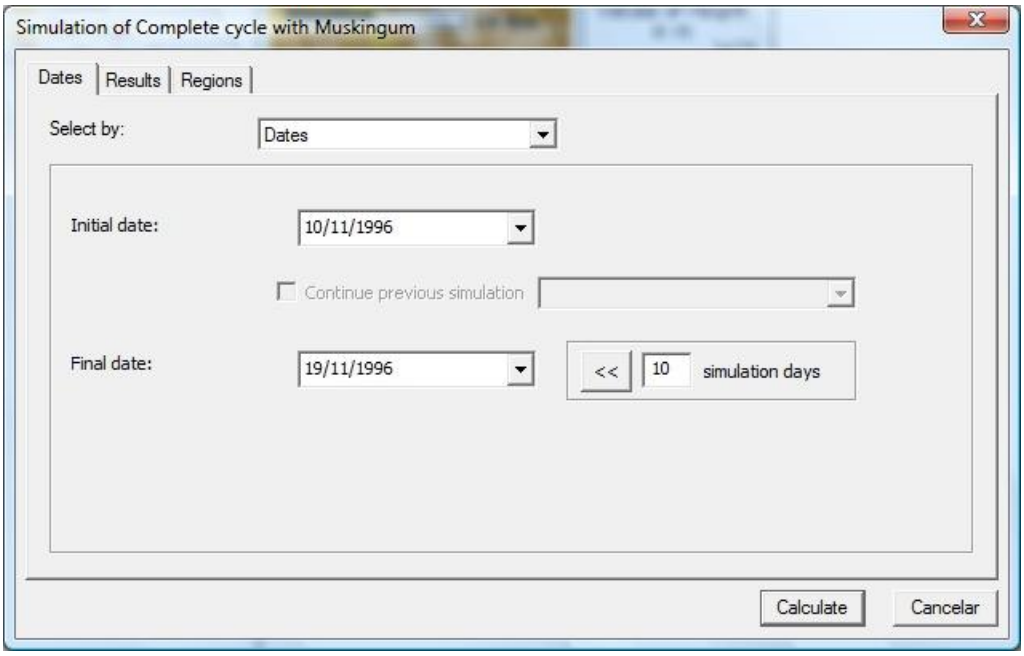

Figure 27. Simulation window. Dates interval.

On the "Dates" tab in the simulation window (Figure 27), the starting and ending dates for the simulation are chosen. To help with the choice, the dates can be defined directly by an expert Windows control (Figure 28), or by using the dates of precipitation events ("Events File" in "Project Properties" - key m2 in Table 4).

The last tab allows you to select the active regions during the simulation based on the map of regions defined by the user (key g1, Figure 17). When you only need results from a particular area, choosing this calculation area greatly reduces the execution time.

Figure 28. Simulation window. Date selection.

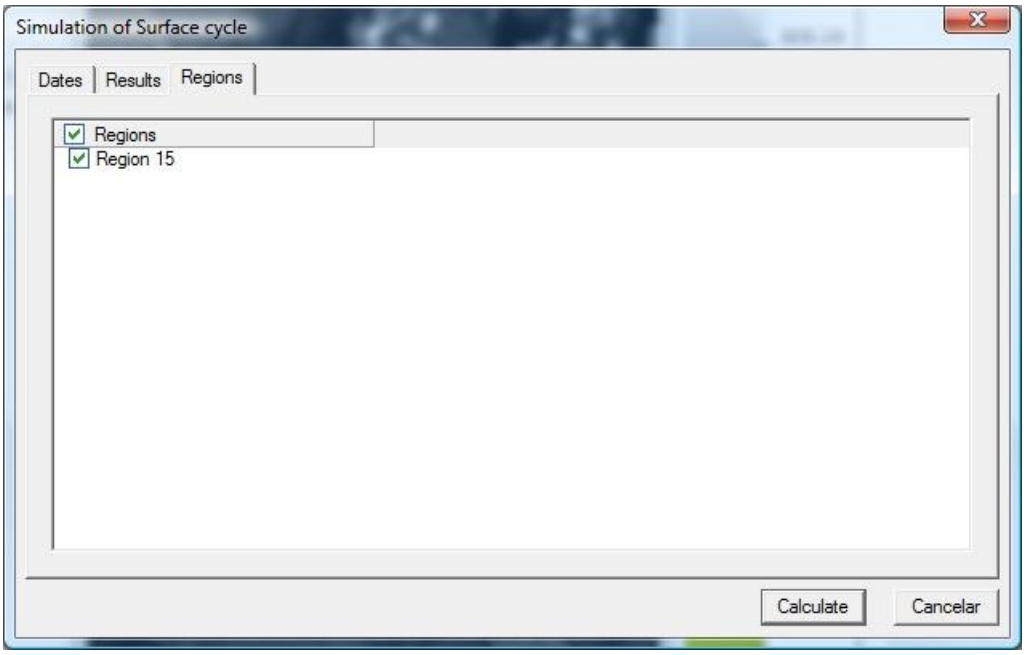

Figure 29. Simulation window. Active regions.

Once the variables, dates and regions have been selected, you can launch the simulation with the *Generate* button. A progress bar indicates that the model is calculating, during which process no action can be taken on the agenda, except to cancel the simulation if needed (Figure 30). The results window (Figure 31) shows the most significant incidents during the loading of data and the current date when the simulation is running. An important feature of this window is if there is an error, it pinpoints the cause, thus allowing for correction. The duration of the calculation depends on the number of cells to simulate, the simulation interval, the number of variables requested and the characteristics of the computer. In the example shown in this tutorial, the period may be as much as several hours.

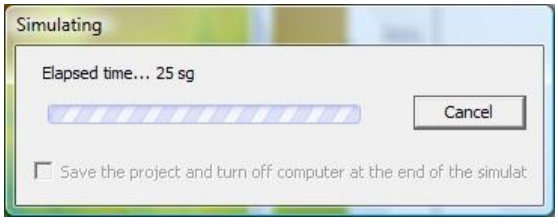

Figure 30. Simulation progress window.

Figure 31. Results window.

Results

Once the calculation has been successfully completed, the simulation results will appear in the *Results* category in the project tree, in a sub-folder with the date and time of when the simulation took place. Previous simulations carried out on the same project are not deleted. Each result variable asked for in map form leads to a map **sequence**, one for each date on which a result has been generated, according to the selected time interval of results. In this way, using the toolbar controls, it can be viewed as a video (Figure 20).

Figure 32 shows the result for the amount of daily snow (equivalent in water, measured in mm) for a simulation lasting 10 days. The screen shows one of the images of the calculated sequence, which consists of 10 maps, as indicated in the project tree after the name of the variable in parentheses. The map title includes the name of the variable and the date which the currently displayed image corresponds to. Each map in the sequence can be exported individually as a Arc-GIS raster file in text format or as an image file, or it can even be printed directly from the tree itself (by right clicking the context menu) or from the *File* menu.

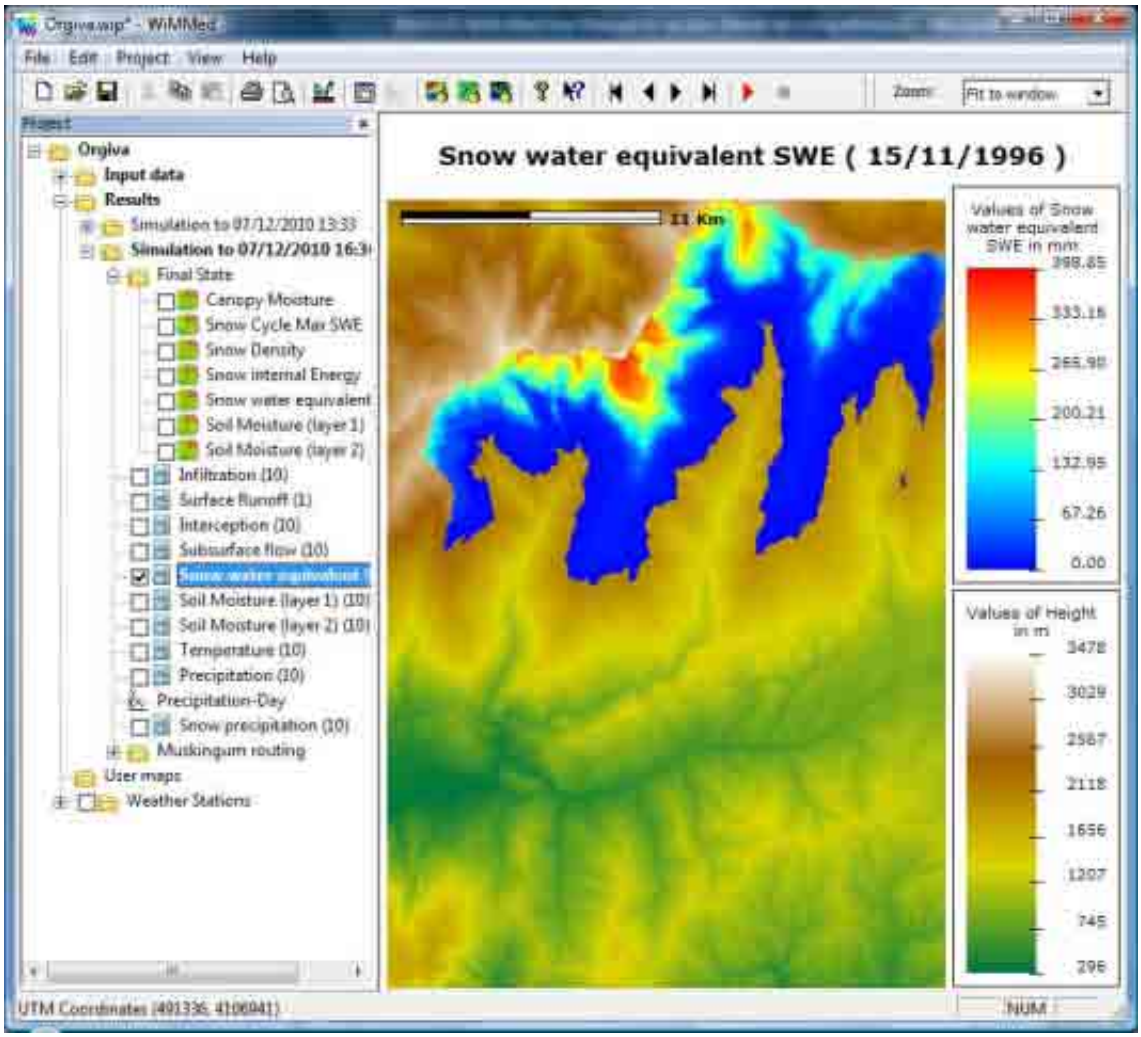

Figure 32. Map of results. Water equivalent of snow.

Figure 33 shows another example from the same simulation - in this case, total daily runoff.

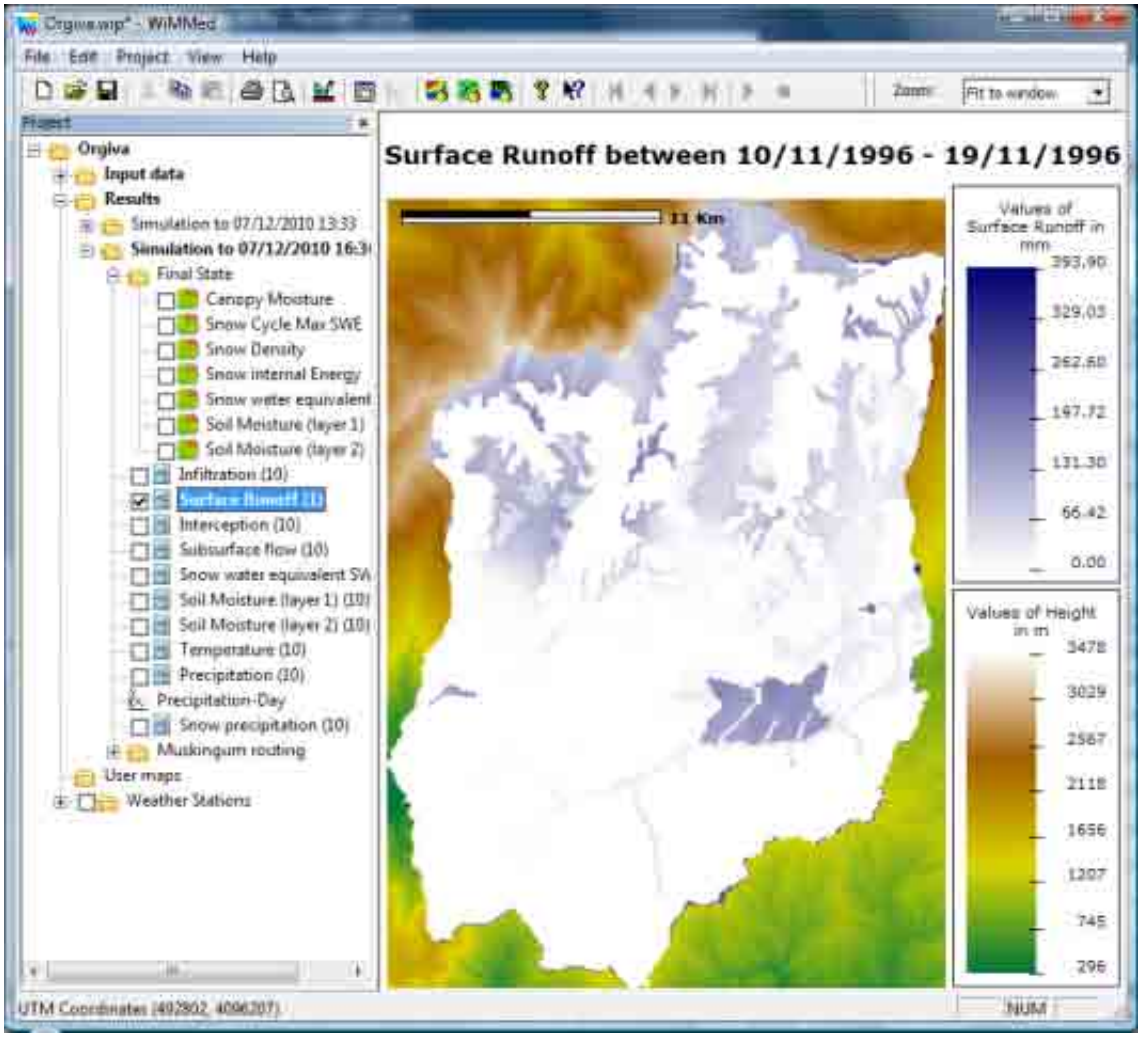

Figure 33. Map of results. Surface runoff.

The maps referring to state variables (such as the water equivalent of snow) represent the instantaneous state on the date of the map, whereas maps of the intermediate variables (such as runoff), and weather maps, represent in some cases the average and in others the accumulated value of that variable from the date of the previous map to the present one.

In the title shown in the geo-referenced display area, appears the name of the variable calculated and a date corresponding to each map in the generated sequence. This date changes according to the element of the sequence represented at each time. If daily results are generated, the simulation date will be shown. With timetables, both the date and time are shown. In the latter case, the hour (HH):00 refers to the fact that this map shows the accumulated, average or final results of the time interval (HH):00 (HH+1):00.

By right-clicking on a results item in the project tree you obtain a drop-down menu from which you can access the general properties of the sequence. As well as the display properties (Figure 25), a tab appears in the window with general information (referred to as *Properties*) about the simulation with which the sequence was generated, namely the starting and ending dates of the simulation, the time step chosen for the results and the type of simulation (Figure 34).

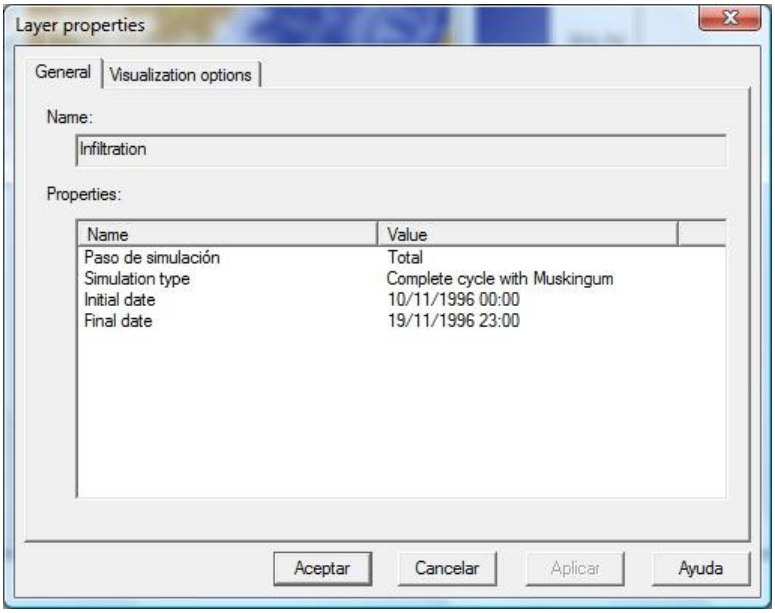

Figure 34. Properties of a sequence of results.

Apart from the results visible directly from WiM-Med, a series of files generated by a simulation is stored on the hard disk inside the project directory (following the path *My documents→ WiMMed Projects →Name of Project*) which can be consulted and copied. These results are:

- Individual maps that make up each of the results sequences
- Results tables accumulated by region (with the identifier AXR in the name)
- Text files showing the mm of water supplied to the drainage points in the form of surface (with the prefix QSup in the name), sub-surface (with the prefix QLat) and underground (prefix Ac_QTot) flow.
- River flow (prefixes: QRio and Daily-QRio). The first has a mixed hourly-daily time scale, and the latter is a daily average (only for Full-cycle simulation with Muskingum).
- Maps with the final values for State Variables, that allow you to continue with the simulation by updating the meteorological data (with the prefix Tot_ and identification of the variable according to the suffix shown in Figure 26).
- Maps of topographical data which are generated in the calculation, but not defined by it (slope, aspect, horizons, SVF, MDR, MDF and Drainage Regions - RD).

Printing. Print preview.

One last post-processing tool of interest is the capability to print a report of the map shown at any time in the general window, with print preview included (Figure 35). This option is accessed from the menu *File-> Print preview* or more directly, *File-> Print*. The map has a caption which includes the properties of the simulation that produced it.

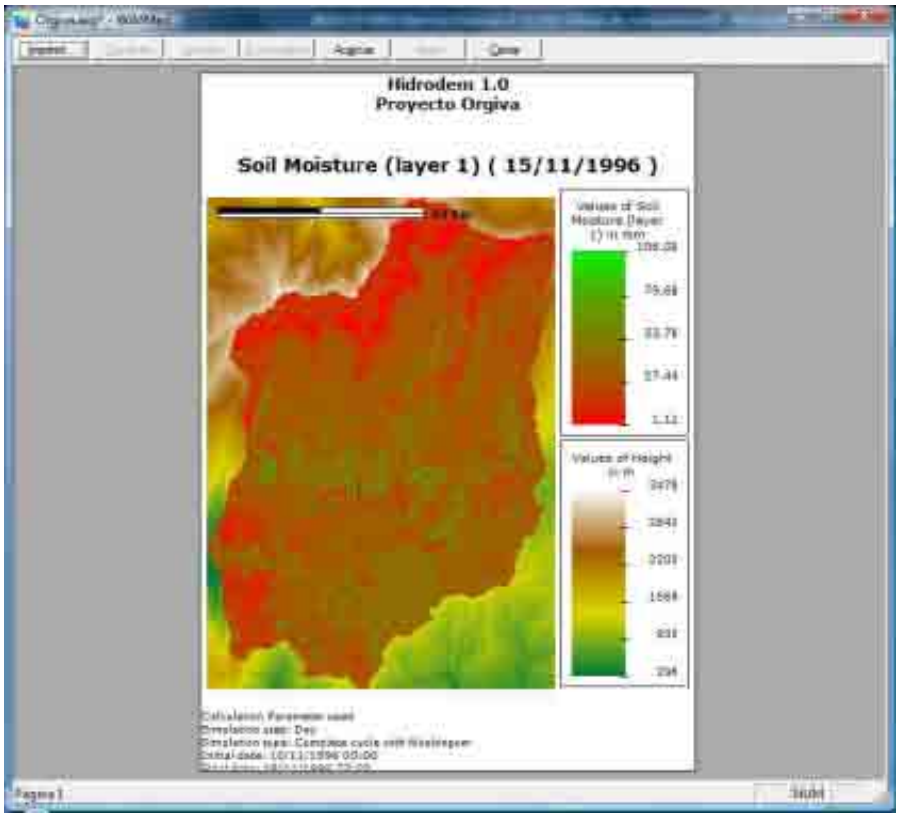

Figure 35. Print Preview.

Appendix A. Organizing the information.

Depending on the simulation chosen, the data required for calculation varies. The following tables show a compilation of all the information you need to define to perform a simulation and the information you can get from it, always depending on the simulation type, as seen in the key in Table 1.

Hydrological Model	Surface Cycle	**S1**
" "	Complete cycle with River (Muskingum)	**S2**
1-D River model	River routing with GuadalFORTRAN	**S3**
Erosion model *	-	**S4**

* In development

Table 1. Types of simulations allowed.

Table 2 shows what data must be defined for each of the two types of hydrological simulation. The data are referred to by a code, consisting of a letter-number combination that corresponds to the variables shown in Table 4.

Entry variables:	S1	S2
s1-s2-s3-s5	*	*
s4		
s6		
s7		
r1→r5	*	*
r6-r7		
g1-g2	*	*
h1-h3		*
h2		*
t1	*	*
t2-t3	(*)	(*)
t4-t5		(*)
t6→t15-t18	*	*
t16-t17	*	*
t20→t28	(*)	(*)
t40-t41	*	*
t42-t43		*
m1→m13	*	*
v1→v8	*	*
d1-d2		*
d3	*	*
c1→c10-c13→c20	*	*
c11-c12		*

* Obligatory data
(*) Data which is useful, but if not available, can be calculated (Calculations based on DEM)

Table 2. List of data required, according to type of simulation.

The following two tables show the data which appear in the project tree (Table 3) and in the properties window (Table 4), and their order.

[Entry data]	[General]	**- Digital Elevation Model**
		- Regions
	[Topography]	**- Slope**
		- Aspect
		- Digital Flow Model
		- Digital Rivers Model
		- Visibility Factor SVF
		- Horizon direction N-S
		- Horizon direction NE-SW
		- Horizon direction E-W
		- Horizon direction SE-NW
		- Horizon direction S-N
		- Horizon direction SW-NE
		- Horizon direction W-E
		- Horizon direction NW-SE
	[Meteorology]	**- Hargreaves' Coefficient**
		- Spatial distribution of hourly P
	[Soil]	**- Saturated Surface Conductivity**
		- Saturated conductivity in soil
		- Capacity of the sub-surface flow contribution
		- Moisture saturation
		- Residual moisture
		- Matric potential of wetting soil
		- Matric potential of drying soil **- Soil thickness (upper layer 1)**
		- Soil thickness (lower layer 2)
		- Van Genuchten's n parameter
	[Plants]	**- Storage capacity of vegetation canopy**
		- Albedo (*)
		- Canopy fraction (*)
	[Hydrology]	**- Aquifers**
		- Speed of surface runoff
		- Speed of sub-surface runoff
	[Erosion]	
[Results]		
[User's maps]		
[Weather	- [Daily precipitation]	
Stations]	- [Hourly precipitation]	
	- [Temperature]	
	- [Radiation]	
	- [Wind speed]	
	- [Vapour pressure]	
	- [Atmospheric emissivity]	

(*) Sequence

Table 3. Data from the tree in the main WiM-Med window.

+General
- Digital Elevation Model (t1)
- Regions (g1)
- Latitude (t16)
- Longitude (t17)
+Topography
- Threshold area for channel calculation [km ²] (d1)
- Correction factor for plains (d2)
- Height above sea level [m] (d3)
+ Advanced:
- Slope (t2)
- Aspect (t3)
- Digital Flow Model DFM (t4)
- Digital River Model DRM (t5)
- Visibility factor SVF (t20)
- Horizon direction N-S (t21)
- Horizon direction NE-SW (t22)
- Horizon direction E-W (t23)
- Horizon direction SE-NW (t24)
- Horizon direction S-N (t25)
- Horizon direction SW-NE (t26)
- Horizon direction W-E (t27)
- Horizon direction NW-SE (t28)
+Meteorology
- Weather Stations (m1)
- Events (m2)
- Hourly precipitation [-] (m3)
- Daily precipitation [mm] (m4)
- Daily Temperature [ºC] (m5)
- Daily solar radiation [MJ] (M6)
- Spatial distribution of the hourly P (m7)
- Hargreaves' coefficient (m9)
- Daily wind speed [m / s] (m10)
- Daily vapour pressure [kPa] (m11)
- Daily long-wave emissivity [MJ / MJ] (m12)
- Starting dates of rainy season (m13)
+Soil
- Saturated surface conductivity (t6
- Saturated soil conductivity (T7)
- Capacity of sub-surface flow contribution (t8)
- Saturation moisture (t9)
- Residual moisture (t10)
- Matric potential of wetting soil (t11)
- Matric potential of drying soil (t12)
- Van Genuchten's n parameter (T18)
- Soil thickness (upper layer 1) (t40)
- Soil thickness (lower layer 2) (T41)
- Speed of surface runoff (t42)
- Speed of sub-surface runoff (T43)
+ Advanced (Soil calculation parameters):
- Time for redistribution of water in soil [h] (c5)
- Exponent "alpha" to express evaporation (c16)
- Coefficient "beta" to express evaporation (c17)
+ Advanced (Calibration coefficients for maps):
- Saturated conductivity on surface (67)

- Saturated conductivity in soil (c7)
- Capacity of sub-surface flow contribution (c8)
- Saturation moisture (c14)
- Residual moisture (c15)
- Matricial potential of moist soil (c10)
- Matricial potential of dry soil (c9)
- Van Genuchten's n parameter (c13)
- Soil thickness (upper layer 1) (c18)
- Soil thickness (lower layer 2) (c19)
- Speed of surface runoff (c11)
- Speed of sub-surface runoff (c12)
+Vegetation
- Storage capacity of vegetation canopy (t13)
- Canopy fraction (t14)
- Albedo (t15)
+Hydrology
- Data from aquifers (h1)
- Aquifer areas (h3)
- Definition of river (h2)
+ Advanced (snow):
- Diffusivity coefficient of recordable heat with no wind (c1)
- Snow roughness [m] (c2)
- Snow recession curve. EA *_100 parameter (c3)
- Snow recession curve. SCmin parameter (c4)
- Temperature with snowfall [ºC] (c20)
+Erosion

* (**blue**: constant, **red**: text file, **black**: map, **green**: sequence)

Table 4. Data in the Project Properties window with codes.

Finally, here are the types of results that can be obtained in each type of simulation, for intermediate variables (Table 5), state variables (Table 6) and meteorological variables (Table 7).

Intermediate Variables	Unit	Suffix	S1	S2	S4
Soil evaporation	mm	EvS	*	*	*
Deep infiltration	mm	Per	*	*	*
Infiltration	mm	Inf	*	*	*
Runoff	mm	Esc	*	*	*
Snow evaporation	mm	EvN	*	*	*
Snowmelt	mm	Fus	*	*	*
Canopy evaporation	mm	EvC	*	*	*
Interception	mm	Int	*	*	*
Frozen Rainfall	mm	Pcg	*	*	*
Sub-surface flow	mm	Qlat	*	*	*
Sediment deposition	Kg/m^2	Dep			*
Inter-furrow erosion	Kg/m^2	Eri			*
Furrow erosion	Kg/m^2	Err			*

Table 5. List of active intermediate variables, according to simulation type.

State Variables	Unit	Suffix	S1	S2	S4
Canopy humidity	mm	HCub	*	*	*
Snow Water equivalent	mm	EAn	*	*	*
Soil moisture Upper Layer1	mm	HSol1	*	*	*
Soil moisture Lower Layer2	mm	HSol2	*	*	*
Internal energy of snow	MJ	U_n	*	*	*
Snow density	kg/l	d_n	*	*	*
EAMax of snow cycle	mm	EAmx	*	*	*
Surface Moisture	mm	HSup			*
Surface Flow mm	mm/h	QSup			*
Active sediment in cell	Kg/m²	PSol			*
Solid flow in cell	Kg/m²·h	QSol			*

Table 6. List of active state variables, according to simulation type.

Meteorological Variables	Unit	Suffix	S1	S2	S4
Long-wave emissivity of atmosphere	MJ/MJ	Eat	*	*	*
Vapour pressure	kPa	e_m	*	*	*
Wind speed	m/s	V_m	*	*	*
ET0	mm	ET0	*	*	*
Solar radiation	MJ	R	*	*	*
Direct solar radiation	MJ	Rdr	*	*	*
Diffuse solar radiation	MJ	Rdf	*	*	*
Temperature	ºC	T_m	*	*	*
Precipitation	mm	Pre	*	*	*
Snowfall	mm	P_n	*	*	*

Table 7. List of active meteorological variables, according to simulation type.

Appendix B. Format of data files.

Raster-map files

Raster-map files are all those that contain spatial morphological information related to matrix cells of the basin, with a value per cell. All these files should be standard import and export *grid* or *ASCII raster*, with data separated by blank spaces, like those used by ArcGIS, so they are readable and can be edited from a standard GIS environment. These files have a heading with *metadata* in the following format:

ncols	*nº-of-columns*
nrows	*nº-of-rows*
xllcorner	*coordinate-x-bottom-left-edge*
yllcorner	*coordinate-y-bottom-left-edge*
cellsize	*size-of-cell-in-m*
NODATA_value	*value-not-considered-as-data*

After this, the data is included, separated by blank spaces in columns and free lines in the rows. *ncols* and *nrows* are the number of rows (Y coordinate) and columns (X coordinate) of the *raster*. *xllcorner* and *yllcorner* refer to the coordinates of bottom left-hand point of the *raster*, *cellsize* to the size of the grid, which must be square, and the *NODATA_value* to the value not considered as data. -9999 is a typical value for this code.

You can also enter the files in WiM-Med binary format, which is just a binary version of the ASCII-ArcGis files. The fact that they are binary allows them to be read and recorded onto disk much faster. In this case, the heading is converted into a sequence of 2 x 2-*byte* integers (C/C++ *short* type) and 4 x 4-*byte* decimal (C/C++ *float* type). Next will follow all the data in *float* format.

Muskingum river network configuration - Drainage points (h2)

This file is used to define significant points in the river network and the properties of the channel sections all together for use in a type S2 simulation (complete simulation with channel flow). WiM-Med deals with complex river networks, formed by any number of branches as the user wants to define. The file is written out with a line for each new item in the channel which you want to define. You can also introduce comment lines preceding them with % symbol. There are two types of items: nodes (joints and junctions) and reaches. The reaches must be defined between existing nodes. The river delineation module automatically join the starting and ending node of each reach and add to it every node over passed during its path. Only the nodes used by an active reach will be part of the river network.

Every node is defined, one per line, with the following information:

- An N character for node.

- Exclusive Id Identifier, from 1 onwards. This identifier is, for example, the one which will later be used in defining the properties of aquifers (h1) or will be show in flow results files.
- UTM coordinates. If any point is not situated in the river channel, as calculated by DFM, it is automatically moved there according to the direction of flow. Repeated points or those situated outside the drainage network will be automatically deleted.
- Gauged or ungauged point (1/0). Every node included in the river network will be treated as a subbasin generator, but only the outflow for the nodes marked as gauged will be stored in the results files.
- Optional description of any length, blank spaces allowed.

Reaches are defined as follows:

- An R character for reach.
- Id identifier of the initial node
- Id identifier of the final node
- Mean value for Manning roughness in the reach
- Mean width of the reach
- Optional description of any length, blank spaces allowed.

The nodes defined in this file are the reference to be used for files of specific results of surface, subsurface and underground flow for the simulation with the 1-D River Model for avenues. The river network defined with the reaches must be coherent. This means that several reaches can share ending joints, but every joint can only be used once as starting point for a reach. One reach can take as ending point an intermediate node belonging to a second reach. In this case, the user must check that the automatic delineation is able to find it in its path from the starting to the ending point of the second reach, or the first reach will remain disconnected from the river network.

In this example, there are two reaches. Main reach (Guadalfeo River) runs from node 1 to node 4. Automatic delineation of this reach crosses over node 3 and consequently split this main reach in two parts. A tributary, Trevélez River, runs from node 2 to node 3. Thus, node 3 works as a junction in this little river network. Only the outflow in node 4 will be stored in the results files:

% Nodes (N id X Y Gauge-OutFlow(1/0) Description):
N 1 482714 4095537 0 Guadalfeo headwater
N 2 478451 4102319 0 Trevélez headwater
N 3 467295 4084157 0 Guadalfeo and Trevélez junction
N 4 466943 4083675 1 Dique del Granadino
% Reaches (R InitialNode FinalNode Active(1/0) Manning MeanWidth(m) Description)
R 1 4 1 0.035 4 Guadalfeo river to Dique del Granadino
R 2 3 1 0.035 3 Trevélez river

Sequence Files

The files for ground cover fraction (t14) and albedo (t15) are map sequence files, which show the available maps for this variable, with date. Each row contains a date and a map. It is not important for the rows to be shown in any given order, either alphabetical or by date. During implementation of the program, the daily map is interpolated from earlier and later versions available at the current date.

The date format will be year/month/day, separated by blank spaces. The file path can include directory modifiers (\), but be careful that the file path is the correct one from the location of this file.

Example:

2002 11 25 .\datos\cubiertavegetal\20021125_fv.bin
2003 01 28 .\datos\cubiertavegetal\20030128_fv.bin

Aquifers file (h1)

The definition of all the parameters necessary for the calculation of the aquifers takes place through a single file (h1) in text format. This file has a heading with **three** comment lines, followed by as many lines as you need to define all the aquifers. Each line includes all the properties of each of these aquifer regions in the following sequence:

- An integer (greater than 0) is used as the ID for the aquifer, which coincides with the ID included in the aquifers map (h3). It is extremely important that the indices for the map and for this configuration file correspond. Indices appearing in this file (h1) which are not included on the map are ignored. Indices found in the map (h3) and not in (h1) will not be resolved, which means they will become non-aquifer cells. IDs do not need to be consecutive.
- 1 / 0 indicates that the aquifer is active / not active for this simulation (which allows you to disable parts of the model without having to make new maps.)
- ID of the drainage point for the aquifer area, according to the key established in the river file (h2). It is valid to use any type of river file point.
- Storage coefficient k^{VZ} for soil transition deposit to the aquifer area, in units of days – decimals can be used.
- Storage coefficient $k^{DRR}cauce$ for the rapid response deposit for the outlet to the channel, in units of days – decimals can be used.
- Storage coefficient $k^{DRR}perc$ for the rapid response deposit for the outlet to the slow response deposit, in units of days – decimals can be used.
- Threshold $h0^{DRR}$ for rapid response deposit for carbonated or detrital material, in mm **of soil** – decimals can be used.
- Specific performance corresponding to the rapid response deposit material Sy^{DRR} , expressed as a decimal fraction.
- Storage coefficient k^{DRL} for the slow response deposit for the outlet to the channel, in units of days – decimals can be used.
- Threshold for the slow response deposit $h0^{DRL}$, in mm **of soil** – decimals can be used.
- Specific performance corresponding to the slow response deposit material Sy^{DRL}, expressed as a decimal fraction.
- Level at the start of the simulation for the rapid response deposit $mm0^{DRR}$ in mm **of water** and using decimals.
- Level at the start of the simulation for the slow response deposit $mm0^{DRR}$ in mm and using decimals.

- Area which contributes to evaporation from aquifer A^{evap} due to the proximity of the water table to the surface, expressed in decimals.
- Minimum threshold of water in the aquifer h^{ET0} for it to produce maximum evaporation (equal to ET0), in mm **of soil.**
- Threshold of the slow response reservoir h_{min}^{Ev} , below which there is no evaporation, in mm **of soil.**
- Free description of the aquifer, with blank spaces, up to the end of the line.

Example:

Aquifers in the Vadose area, + aquifer as two deposits in line
Guadalfeo River Basin
Id Act IdP kVZ kRc kRp h0R SyR kL h0L SyL mmVZ mmR mmL Aev hET0 hminEv Description
1 0 1 5 10 3 0 0.99 17 0 0.99 0 0 0 0.01 5 1 Cádiar aquifer area
3 0 6 10 10 5 0 0.99 25 5 0.99 0 0 0 0.05 5 1 Contraviesa aquifer area

Files of meteorological stations (m1)

This file is useful to determine the location and height of all the meteorological stations which may be used in any of the meteorological data files. Each station is defined through a series of data: identifying code, X-coordinate, Y-coordinate, height and name. Even if the station itself is the source of more than one weather record, it is not necessary to include it more than once in this file. In the heading of the meteorological files which require station identification (m3-m6 and m10-m12) it will be referred to with the identifier assigned to this file, which is an integer greater than 0. The station name is given solely for information purposes, and is formed by a line of characters. Coordinates X, Y and Z may include decimals.

Therefore, in the meteorological stations file there will be a line for each station. In each line, the following information, separated by spaces, will appear:

Station No. X-Coordinate Y-Coordinate Z-Coordinate Station name

Example:

2 481882 4071816 246 ALBUÑOL
3 443816 4087267 734 ALBUÑUELAS
6 438464 4065578 30 ALMUÑECAR
27 486254 4092793 1208 MECINA BOMBARON

Meteorological data files

The different files with the meteorological variables to be used (measured or calculated outside WiM-Med) open at the beginning of the simulation and the data can be accessed

when it is needed. Each row of the file contains the data at all the stations for a given day. The first row indicates the day the data started and after that, the values of all the consecutive days are given, with a new row for each day of data. To avoid unnecessary calculation time, the data is not stored except for the cumulative variables that are considered appropriate. The meteorological data includes daily and hourly rainfall, typical daily temperatures (maximum, minimum and mean), daily accumulated radiation, daily mean vapor pressure, average daily atmospheric emissivity and average daily wind speed. The format of all these files will be similar for any meteorological variable; in no cases are incomplete series allowed and all values will be taken literally as valid (including -9999). February 29th in leap years will always be included.

The file configuration is, then, as follows:

- a first row with the starting date of data in the dd mm yyyy format.
- a second row with the index for the stations corresponding to each of the subsequent measurements, in the same order as the subsequent data. This index should be the same as that which appears in the file of meteorological stations (M1).
- next, in sequence, one row for each day of data. In the daily files, there is usually one item of data each day in each season. But in the temperature files, there are three items of data per station and day, ordered as maximum temperature, minimum temperature, and then mean temperature. Also, the hourly files, each station will have 24 items of data, one for each hour.

Example of daily temperature file:

25 1 2001
32 92 93
14 4 9 13.8 9.4 11.6 8 0.2 4.1
22 10 16 17 10.6 13.8 11.4 4.2 7.8
14 5 9.5 15.6 4 9.8 9.4 -1.2 4.1

Example of daily rainfall file:

1 9 1968
2 3 6
0 0 0
0 0 0
0 0 0
1.2 3.5 5.0
0 1.0 2.2
0 0 0
0 0 0

File of weather events (m2)

The proposed physical model considers the event as the main meteorological driving-force in the Guadalfeo river basin. Events, associated with storms that leave rainfall over the basin, last for a series of consecutive days, during which the processes dealt with by the model are different from those simulated during the periods between events. Events-storms are numbered and catalogued. The index of the event corresponding to each day

after a given date will be entered in this file, with a 0 for those days when there is no event in the watershed. Generating this database of events is important, because on those days when the event is classified as 0, the model will not take rainfall into account, even if there is data indicating daily or hourly precipitation.

The format is exactly the same as that of meteorological data, except for the second row of stations, which is omitted, since the event is general and is not linked to specific points. The first valid item of data begins after the date line.

Example:

1 9 1968
0
0
0
1
1
0
0
0
2
2
2
2
0

Appendix C. Spatial structure of calculations

The simulation of the hydrological cycle with WiM-Med involves a variety of elements on different spatial scales which interact with each other in different ways. To analyze the results correctly, and efficiently manage entry data, it is necessary to understand these relationships, which are sometimes complex – therefore, they are illustrated visually in this chapter, so as to facilitate understanding.

General scheme

The simulated cycle starts with the distributed calculation of rain and other meteorological variables necessary in each active cell in the domain of study. The mass and energy balance in each of the deposits associated with each cell allows us to obtain, for every state, interception values, evaporation from the ground cover, evaporation from the snow, snowmelt, surface runoff, infiltration, soil evaporation and seepage into the aquifer, along with mass and energy levels of deposits. Surface runoff is transported via a circulation model from each cell of origin to previously-selected drainage points. Simultaneously, the ground water is added in deposits related to the aquifer that also trigger flow at specific points, according to their levels. This, in simplified form, is the mechanism used to make the change from the distributed scale of the terrain and rainfall to the spatially discrete scale of the channel.

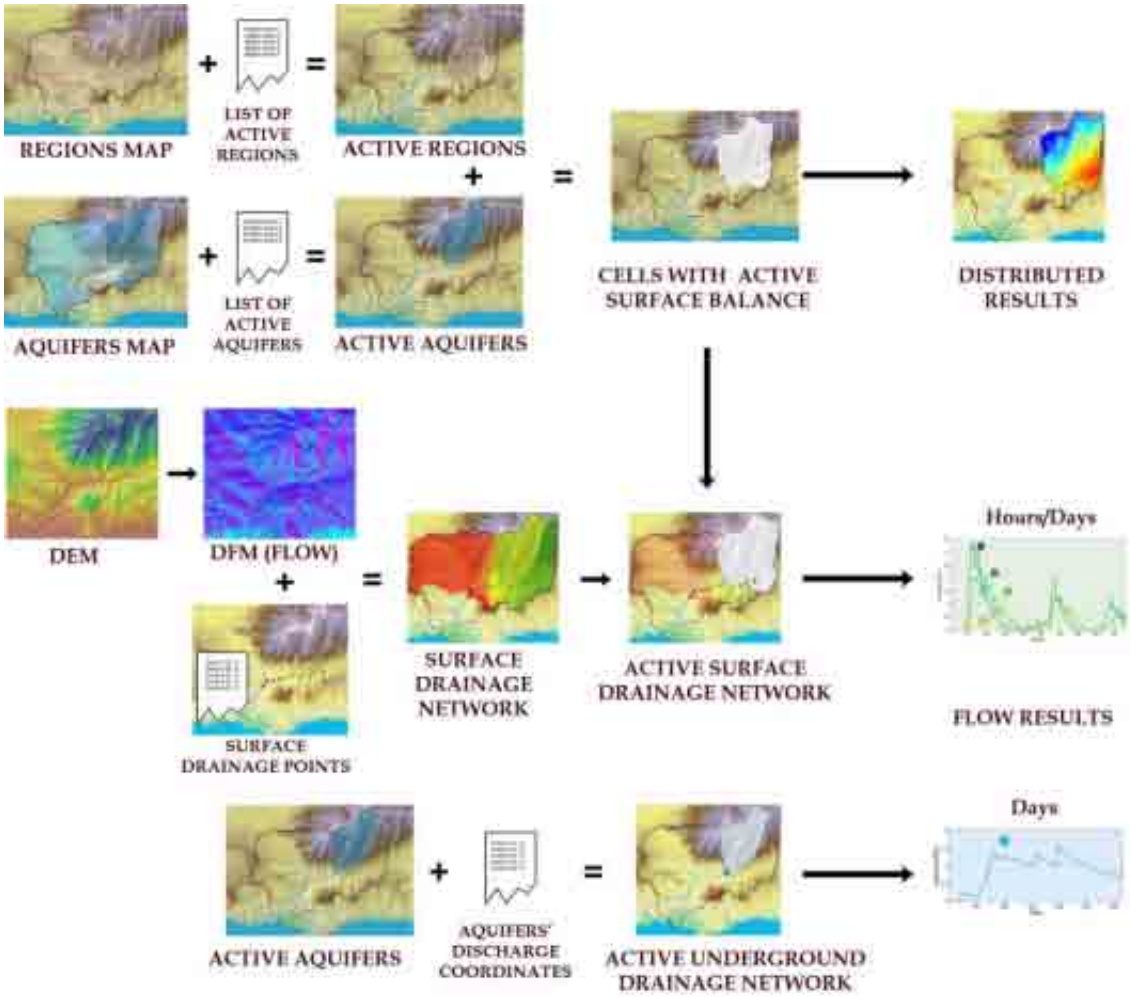

Figure 36. General scheme of the spatial relationship between elements of WiM-Med.

Figure 36 shows the general scheme of the data which influences the spatial extent of the calculation and the transfer of distributed results to other discrete items – usually, flow. In this set of scales and domains, the users' regions, aquifer areas, sub-basins automatically extracted from the digital flow model and the aquifer drainage points are all mixed together. Later, we will look in more detail at each part of this scheme.

Cells with surface balance

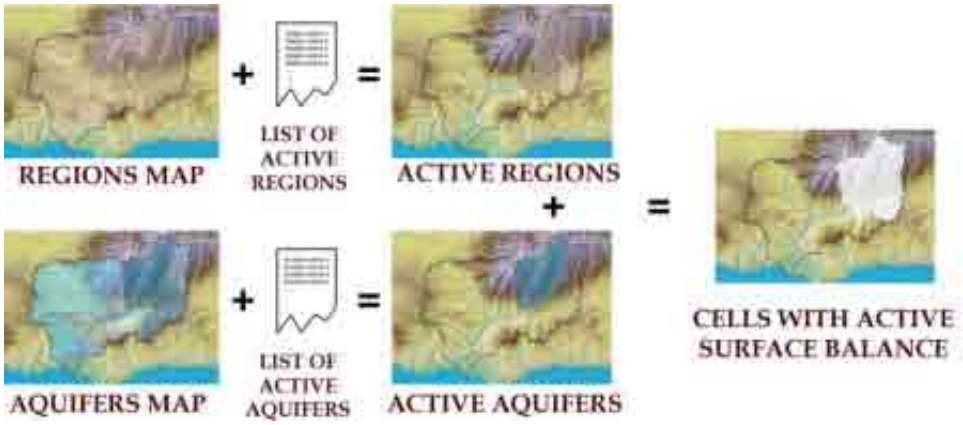

Figure 37. Scheme of cell determination with active surface balance.

Not all the DEM cells are active. Calculations will only be made for those specifically indicated. These will be defined by the intersection of the cells in the areas which are activated for the simulation with the aquifer cells which are activated (in h1).

The so-called user areas refer to arbitrary extensions which may have some physical, hydrological or practical meaning for the user, and which may provide results of any variable accumulated by each region at different time scales.

Aquifer areas, on the other hand, are defined by the user. An aquifer area may contain cells from outside the surface sub-basin beneath which it lies, or even outside the main basin, if the characteristics of groundwater flow are such. Also, cells within the basin may not be considered as inside any aquifer area of that basin, which is the same as saying that the infiltrated water in them flows out of the basin.

This working scheme lends the program enough flexibility to be able to simulate complete watersheds or only parts of them; the whole aquifer system or only particular aquifers. All this is possible without having to change the maps that define the regions – all that needs to be changed are the lists that mark active areas for the present simulation.

For all the cells with an active surface balance, the interpolation and distribution of meteorological variables will be carried out, and all calculations of mass and energy balance that are relevant to the type of simulation chosen will be performed.

Cells with circulation on slopes

The surface drainage system will be automatically calculated by the model through the DFM (t4) digital flow model (which, in turn, is read or calculated from the DEM) and from the list of surface drainage points defined in the river (h2). With a consistent DFM, the program will calculate the sub-basins which belong to each of the points read. However, it is the user's responsibility to compare the consistency or agreement of the results obtained with expected results. To facilitate this, WiM-Med will save, whenever you need to calculate it, the DRM digital rivers model and the map of drainage regions or DR sub-basins which are deduced from the data in the results directory.

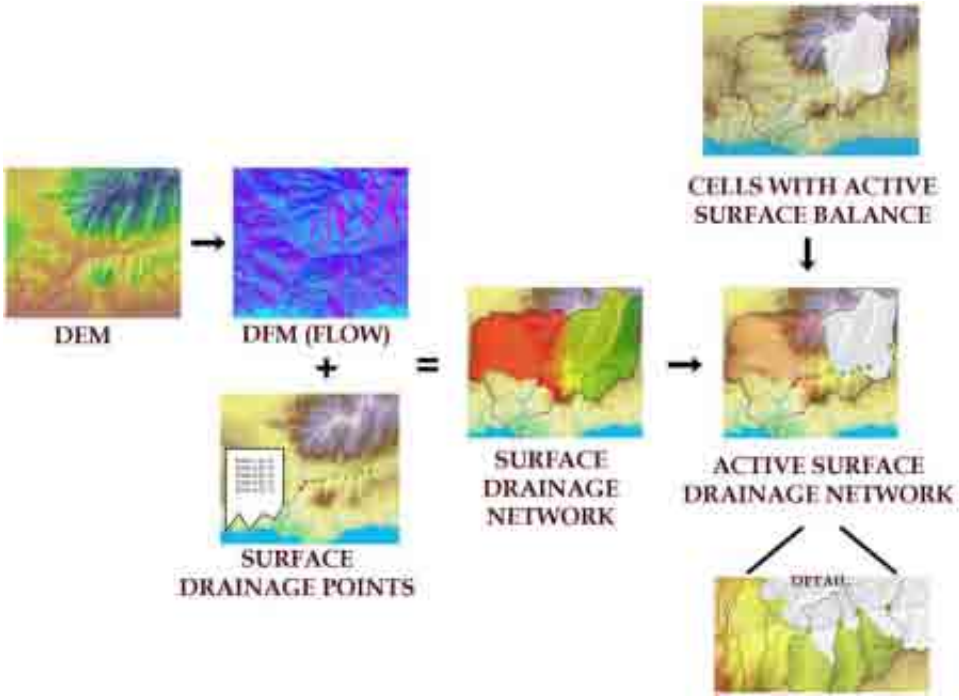

Figure 38. Scheme for determining the active surface drainage network.

To calculate these sub-basins (the DR map), a particular draining point to any cell which is not active on the surface can even be included as a contributing area. In this case, the cell in question will not contribute to flow at that point since the surface balance has no effect on it. This is what happens in the detail in Figure 38, where parts of the four sub-basins that extend towards the south are in non-active cells and they are therefore not contributing to runoff. If any of the sub-basins for one of the drainage points does not contain any active cells, it will appear in the result file of surface flows but with a result of zero for all the time states.

The common practice will obviously be to use user regions which match with existing major sub-basins in the study area, but in this case, we must not forget that the real sub-basins for the model will always be those deduced from the DFM and the drainage points, and that the only utility of the user's regions will be to define active cells and to define accumulation areas and average results.

Cells which contribute to aquifers

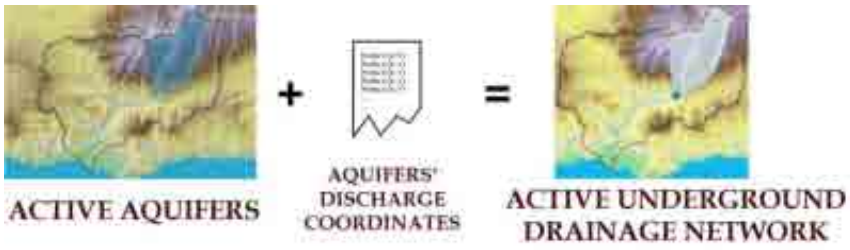

Figure 39. Scheme for determining the active underground drainage system and its contributing cells.

Each region has an associated active drainage point (h2), where, supposedly, all its water flow pours. This point does not necessarily have to be in the area, but it does have to be on the network of channels as defined in h2. The series of points, one for each active aquifer, determines the underground drainage network.

Point flow results

The reasons for changing from the distributed to the point scale are based on the drainage networks. The balance of mass in the underground reservoirs will result in a flow for each aquifer area, which, due to the underground drainage system, allows an average level of water to pass in an extension to a sporadic flow which is distributed in time. In turn, the circulation of surface runoff through the DFM will concentrate the water at specific closing points of the sub-basins with their corresponding phase interval.

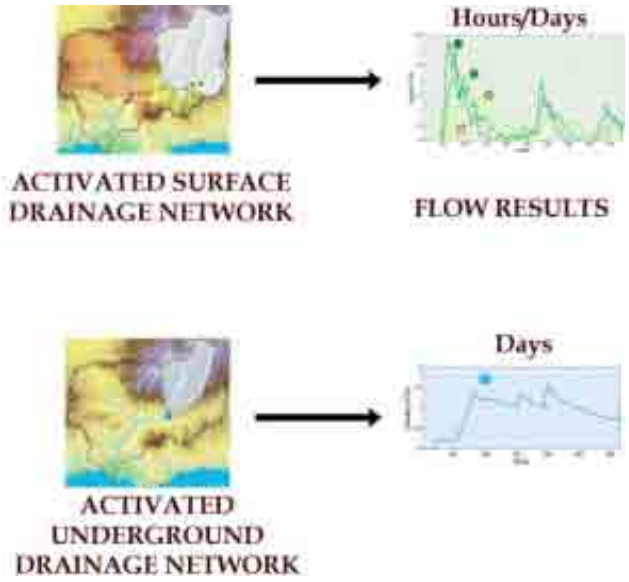

Figure 40. Scheme for the generation of sporadic flow from drainage networks.

Results distributed by cell

Figure 41. Scheme for the generation of distributed results using active cells.

Furthermore, the distributed results which you want to save will be saved in map form showing results in all the active cells, irrespective of whether they are in the user's region or the aquifer area. The accumulated results by region will be shown, obviously, only in those regions defined by the user and activated by them, and therefore, there does not need to be a correspondence between both sets of results (distributed and accumulated).